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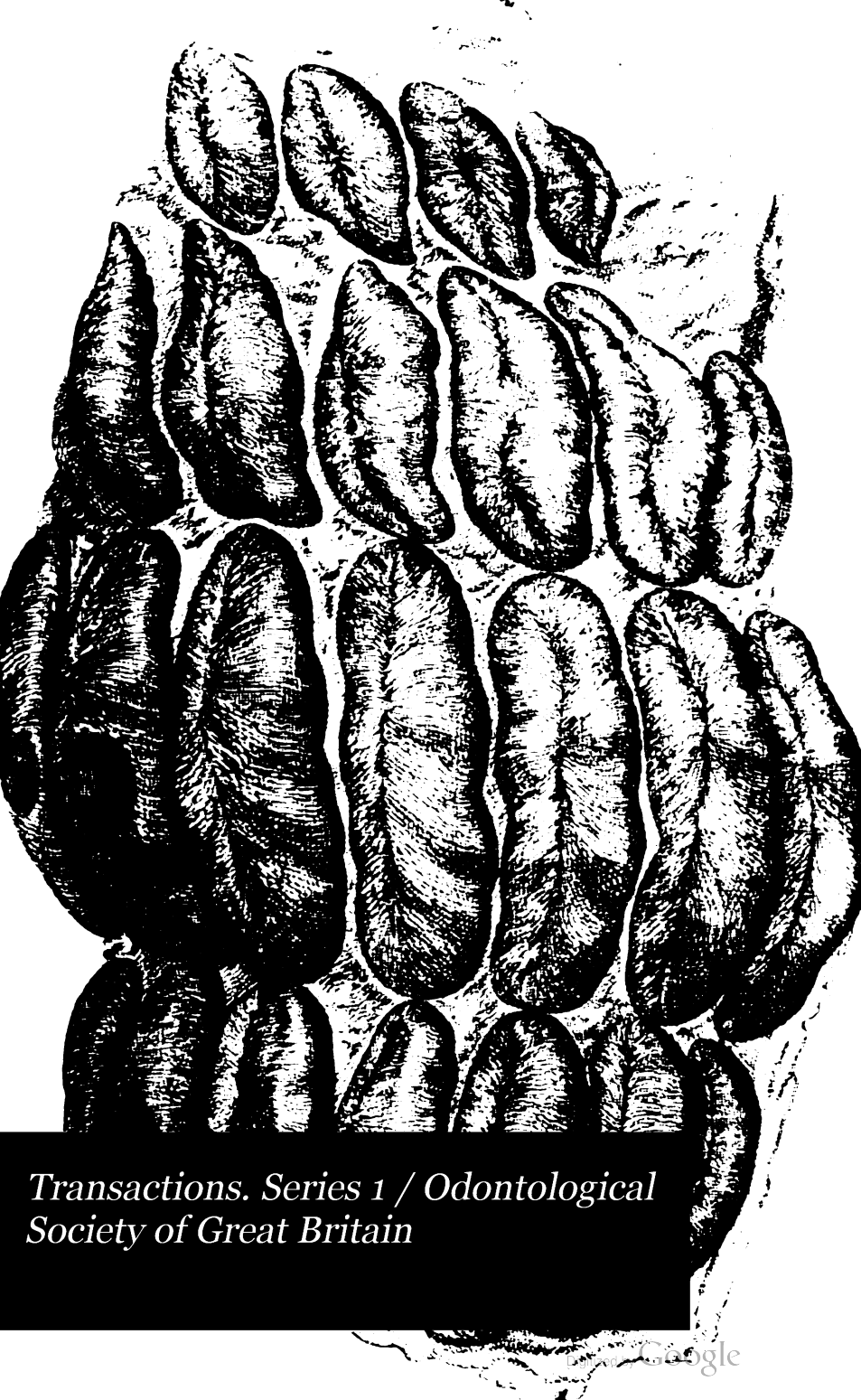

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BRADFORD	1863	SUTCLIFFE, JAMES, L.D.S. 57, Drewton Street, North Parade.
BRIGHTON	1862	FOX, O. A., L.D.S. 12, Pavilion Parade.
	1856	PARKINSON, EDWARD P., L.D.S. 10, Old Steine. (C. 1864-65, V.P. 1862.)
	1863	WOOD, W. R., L.D.S. Carlisle House, Pavilion Buildings.
	1863	WOOD, J. Carlisle House, Pavilion Buildings.
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	1863	LITTLE, S. 4, Cumberland Street.
	1863	PARSON, T. C. 3, Great George Street, Park Street.
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	1864	PALMER, T. W. G., L.D.S. 1, Royal Crescent.
	1863	ROGERS, R. 58, Regent Street.
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	1863	STEELE, J., L.D.S. 63, High Street.
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	1863	FOTHERGILL, W., L.D.S.
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Dewsbury	1863	MARGETSON, W., L.D.S. Roscoe Place.
Dover	1863	ASH, G., L.D.S. 7, Castle Street.
	1857	LINDSEY, JOHN BURKE, L.D.S. 1, Maison Dieu Road.
Dublin.....	1859	BAKER, JOHN A., Licentiate and F.R.C.S. Ire. by Exm. 4, Clare Street, Merrion Square. (C. 1865-66.)
	1861	CORBETT, DANIEL, M.R.C.S. Eng., & L.D.S. 12, Clare Street.
	1865	DOHERTY, WILLIAM IZOD, L.D.S. 21, Westland Row.
	1863	MACKINTOSH, W. 117, Stephen's Green.
	1864	M'CLEAN, F., Jun. 10, St. Stephen's Green North.
	1859	MOORE, ROBERT H., F.R.C.S. Ire. 28, Upper Merrion Street. (C. 1861-62, V.P. 1865-66-67.)
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EDINBURGH	1859	CHISHOLM, JOHN KNOX, L.D.S. Duke Street.
	1859	HEPBURN, DAVID, L.D.S. 7, Abercrombie Place. (C. 1863-64.)
	1857	NASMYTH ROBERT, F.R.S.Edin., F.R.C.S. Edin. 5, Charlotte Square. (V.P. 1857-58-59.)
	1859	ORPHOOT, PETER, M.D.Edin. 113, George Street.
	1859	ROBERTS, W. A., L.D.S. 30, Queen Street. (V.P. 1864-65-66.)
EGYPT	1859	FINNIE, JOHN. Alexandria. (*Corresponding.*)
EPSOM	1864	KEELING, G. R., L.D.S.
EXETER	1858	BRAND, EDWARD E. Cathedral Yard.
	1863	KING, N. 7, Bedford Circus. (C. 1866-67.)
	1864	MASON, J. T. BROWNE, L.D.S. Palace Gate.
	1856	SHEFFIELD, THOMAS. Palace Gate. (C. 1858.)
FLORENCE	1857	DUNN, CHARLES W., L.D.S. 4245, Piazza Santa Maria Novella. (*Honorary.*)
GLASGOW	1864	AGNEW, JOSEPH. 47, Bath Street.
	1860	BELL, J., L.D.S. 261, West George Street, Blythswood Square.
	1856	BUCHANAN, G. 1, Montague Place, Bath Street. (C. 1864.)
	1863	HORNE, J. 121, Douglas Street, Blythswood Square.
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	1863	YOUNG, J. H. 34, Dundas Street.
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	1867	APPERLEY, EBENEZER, L.D.S. Stroud.
Guernsey	1858	HUGO, SAMUEL GEORGE JOSEPH. 15, Allez Street, New Town.
Hereford	1857	M'ADAM, GEORGE W. King Street.
Hull	1864	WILSON, G. 4, White-Friar Gate.
India	1863	LLOYD, FRANCIS ROBERT. Agra.
	1859	O'MEARA, ALFRED. Simla.
	1863	SHORTT, J., L.D.S. Zillah Singen, Chingleput.
Inverness	1863	GRANT, W. 20, Church Street.
Ipswich	1864	COLE, J. F., L.D.S. 11, Museum Street.
Ireland	1867	ENNISKILLEN, Earl of, F.R.S., &c. Florence Court, Fermanagh. (*Honorary.*)
Isle of Man ...	1863	GARRETT, P. L. 56, Athol Street, Douglas.
	1863	KARRAN, J. 2, Finch.Road, Douglas.
Isle of Wight .	1863	ALABONE, ALFRED. 113, High Street, Newport.
	1863	HARRINGTON, G. F., L.D.S. Sedgeley House, Ryde.
Jamaica	1860	CALORIE, JOSEPH.
Kingston-on-Thames ...	1867	MAKINS, G. H., M.R.C.S., L.S.A. Blenheim Lodge, Surbiton. (*Honorary.*)

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Leicester	1857	DUFF, A. M., L.D.S. 37, Gallow-Tree Gate.
	1865	KIRBY, H. T., L.D.S. 4, Market Street,
Liverpool	1863	NEWMAN, W. J. 27, Great George Street.
	1863	ROSE, J. E. 64, Mount Pleasant.
	1858	SNAPE, JOSEPH, L.D.S. 75, Rodney Street.
	1861	STEWART, ROBERT EDWARD, L.D.S. 37, Rodney Street.
	1863	WAITE, W. H., D.D.S. 10, Oxford Street, Abercrombie Square.
London	1858	ANDERSON, JAMES. 15, Margaret Street, Cavendish Square.
	1862	ARNOTT, J. M., F.R.S., &c. 6, Chandos Street, Cavendish Square. (*Honorary.*)
	1859	BALLARD, W. R. 25, Manchester Square.
	1856	BARRETT, HENRY JOHN, M.R.C.S.Eng., & L.D.S. 42, Finsbury Square. (C. 1856-57-58, 1860-61, V.P. 1866-67.)
	1859	BARTLETT, EDWARD B., L.D.S. 38, Connaught Square.
	1867	BARTLETT, W. P., L.D.S. Eastbourne Terrace, Hyde Park.
	1867	BEALE, LIONEL S., M.D., F.R.S. 61, Grosvenor Street. (*Honorary.*)

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LONDON	1862	BELL, THOMAS, F.R.S., P.L.S., F.G.S., F.R.C.S.Eng., L.D.S., & F.R.M.C.S. The Wakes, Selborne, Hants. (*Honorary.*)
	1859	BENNETT, W. G., L.D.S. 17, George Street, Hanover Square.
	1863	BROCK, J., L.D.S. 62, Margaret Street, Cavendish Square.
	1867	BUSH, JOHN D., M.R.C.S.Eng. 16, Hanover Square.
	1867	BUSK, GEORGE, F.R.S., &c. 15, Harley Street. (*Honorary.*)
	1856	CANTON, ALFRED G., M.R.C.S.Eng., & L.D.S. 17, Great Marlborough Street. (C. 1856, 57-58, H.S. 1859-60-61, H.F.S. 1862-63.)
	1863	CANTON, W. L. 18, Hanover Street.
	1856	CARTWRIGHT, SAMUEL, F.R.C.S.Eng., L.D.S., &c. 32, Old Burlington Street. (H.S. 1856-57-58, H.F.S. 1859, V.P. 1860-61-62, P. 1863, C. 1865-66-67.)
	1856	CATTLIN, W. A. N., F.R.C.S.Eng. & L.D.S. 1, Highbury Place, Islington. (C. 1860-61-62, V.P. 1863-64-65, P. 1866.)
	1859	CATTLIN, W., M.R.C.S.Eng. & L.D.S. 1, Highbury Place, Islington.
	1857	COLEMAN, ALFRED, M.R.C.S.Eng. & L.D.S. 32, Old Burlington Street. (C. 1861, H.S. 1862-63-64-65, C. 1867.)
	1867	COLES, JAMES O. 68, Wimpole Street.
	1856	DREW, JOHN. 13, New Burlington Street. (C. 1861-62, H.S. 1866-67.)

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	1863	FINZI, S. L., L.D.S. 105, Gower Street.
	1856	FLETCHER, JOHN B., L.D.S. 17, New Burlington Street. (C. 1859-60-61, L. 1862-63-64-65-66-67.)
	1860	FORSYTH, W. F., L.D.S. 13A, George Street, Hanover Square.
	1856	FOX, CHARLES JAMES, M.R.C.S.Eng., L.D.S. 27, Mortimer Street, Cavendish Square. (C. 1863-64-65, H.S. 1867.)
	1863	FRANKLIN, G. P. 109, Westbourne Grove, Bayswater.
	1862	GIBBONS, S. C., L.D.S. 13, New Burlington St.
	1863	GILBERT, W. J., L.D.S. 4, Old Quebec Street.
	1866	GOODE, JOHN SAXTY, L.D.S. 17, Lower Phillimore Place, Kensington.
	1857	GREGSON, G., M.R.C.S.Eng. 26, Harley Street. (C. 1867.)
	1867	HARDING, HENRY, L.D.S. 10, Park Square, Regent's Park.
	1856	HARRISON, W. A., F.R.C.S.Eng., L.D.S. L.S.A., &c. 10, Keppel Street, Russell Square. (V.P. 1857-58-59, P. 1860, C. 1862-63-64-66-67.)
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	1863	HENRY, G., L.D.S. 22, Poultry, City.
	1859	HEPBURN, ROBERT, L.D.S., &c. &c. 70, Portland Place, Cavendish Square. (C. 1862-66, V.P. 1867.)
	1861	HILL, ALFRED, L.D.S. 23, Henrietta Street, Cavendish Square. (C. 1864-65-66.)
	1863	HOCKLEY, A., L.D.S. 45, Great Marlborough Street.
	1863	HULME, R. T., M.R.C.S.Eng. 75, Margaret Street. (C. 1863-64-65-66-67.)
	1862	HUXLEY, T. H., F.R.S., &c. 26, Abbey Place, Abbey Road, St. John's Wood. (*Honorary.*)
	1856	IBBETSON, GEORGE A., F.R.C.S.Eng., L.D.S., F.G.S., &c. 30, Cavendish Square. (C. 1857-58-59, H.S. 1860-61-62, C. 1863, V.P. 1864-65-66, P. 1867.)
	1857	JONES, A. B., M.R.C.S.Eng. & L.D.S. 53, Brook Street, Grosvenor Square.
	1863	KEMPTON, H. T., L.D.S. 17, Cavendish Place. (C. 1863-64-65-66.)
	1864	KING, E. H., M.R.C.S. & L.D.S. 18, Stratford Place.
	1867	LANE, EDWIN F., L.D.S. 10, Keppel Street.

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	1860	MAY, WILLIAM H. 26, Guildford Street, Russell Square.
	1864	MERRYWEATHER, JAMES, M.R.C.S. 57, Lower Brook Street.
	1867	MORTIMER, JOHN E. 12, Great Castle Street, Regent Street.
	1856	MUMMERY, JOHN R., L.D.S., F.L.S. 10, Cavendish Place. (C. 1861-62-63.)
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	1856	PARKINSON, JAMES, L.D.S. 36, Sackville Street. (C. 1857-58-59, C. 1863, V.P. 1865-66-67.)
	1860	PARKINSON, GEORGE, M.R.C.S.Eng., L.S.A. 16, Brook Street.
	1860	PARKS, WILLIAM J., L.D.S. 27, Newington Crescent, Kennington Park Road.
	1863	PERKINS, H. J., L.D.S. 379, City Road.
	1863	PORTER, W. P. 15, Finsbury Place South.

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	1863	RAMSAY, ROBERT. 68, Wimpole Street.
	1866	REBOUL, A. P., L.D.S. 5, King Edward Terrace, Liverpool Road, Islington.
	1863	RICHARDSON, Dr. 12, Hind Street, Manchester Square. (*Honorary.*)
	1856	ROGERS, ARNOLD, F.R.C.S.Eng., L.D.S., F.G.S., &c. 16, Hanover Square. (V.P. 1857-58, P. 1859, T. 1861-62-63-64-65-66-67.)
	1856	ROGERS, THOMAS ARNOLD, M.R.C.S.Eng. & L.D.S. 16, Hanover Square. (H.S. 1856-57-58-59, H.F.S. 1860-61, V.P. 1862-63-64, P. 1865.)
	1856	ROGERS, HENRY, M.R.C.S.Eng. & L.D.S. 16, Hanover Square.
	1859	ROGERS, JOSEPH, M.R.C.S.Eng. & L.D.S. 16, Hanover Square.
	1856	ROGERS, CHARLES, L.D.S. 2, Cork Street, Burlington Gardens. (C. 1862, H.S. 1866, H.F.S. 1867.)
	1863	ROSS, G., L.D.S. 16, South Street, Finsbury Square.
	1860	SALTER, S. J. A., M.B., M.R.C.S.Eng. & L.D.S. 17, New Broad Street.
	1856	SAUNDERS, EDWIN, F.R.C.S.Eng., &c. &c. 13A, George Street, Hanover Square. (T. 1856-57-58-59-60, V.P. 1861-62-63, P. 1864.)
	1856	SAUNDERS, JOSIAH, L.D.S. 42, Albemarle Street. (C. 1865-66-67.)
	1856	SERCOMBE, EDWIN, M.R.C.S.Eng. & L.D.S. 49, Brook Street. (C. 1859-60-61.)

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	1862	SHARPEY, W., M.D., F.R.S. 33, Woburn Place. (*Honorary.*)
	1856	SHEFFIELD, ISAAC. 2, Stratford Place. (C. 1861-62-63-64-65.)
	1866	SKEY, F. CARPENTER, F.R.C.S.Eng. 2, Mount Street, Grosvenor Square. (*Honorary.*)
	1863	SMITH, J. A., L.D.S. 47, Smith Street, Chelsea.
	1866	SPENCER, H. L. 16, Orchard Street.
	1857	STATHAM, JOHN LEE, L.D.S. 60, Wimpole Street.
	1858	STEVENSON, NATHANIEL, M.R.C.S.Eng. & L.D.S. 51, Wimpole Street. (C. 1863-65.)
	1863	TIBBS, S. Tor Villa, St. John's Road, Brixton. (V.P. 1863-64-65.)
	1856	TOMES, JOHN, F.R.S., M.R.C.S.Eng., L.D.S., &c. &c. 37, Cavendish Square. (H.S. 1856-57-58, V.P. 1859-60-61, P. 1862, C. 1864-66-67.)
	1862	TREVELYAN, Sir C., K.C.B. 5, Grosvenor Crescent. (*Honorary.*)
	1861	TRUMAN, EDWIN, M.R.C.S.Eng., F.R.M.C.S., &c. 23, Old Burlington Street.
	1867	TURNER, J. S., M.R.C.S.Eng., L.D.S. 30, Margaret Street.
	1859	UNDERWOOD, THOMAS, L.D.S., &c. 14, Gower Street, Bedford Square. (C. 1860-61-62, H.F.S. 1864-65-66.)
	1863	USHER, C. H. A., L.D.S. 2, Arnold Terrace, Bow Road.

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	Elected	
London	1866	VANDERPANT, H. L. 52, Maddox Street.
	1856	VASEY, CHARLES, L.F.P.S. & L.D.S. 5, Cavendish Place. (C. 1862, H.S. 1863-64-65, C. 1867.)
	1863	VIDLER, T. C., L.D.S. 22, Eastbourne Terrace.
	1857	WALKINSHAW, BURNLEY, L.D.S. 8, Princes Street, Cavendish Square.
	1863	WALKER, GILBERT, L.D.S. 28, New Kent Road.
	1860	WALKER, JOSEPH, M.R.C.S.Eng. & L.D.S. 22, Grosvenor Street.
	1863	WEAVER, G., L.D.S. 41, Upper Baker Street.
	1863	WEISS, F., L.D.S. 32, Great Russell Street. (C. 1865-66.)
	1857	WEST, BYATT. 69, Old Broad Street, City.
	1863	WEST, C., L.D.S. 343, Hackney Road.
	1863	WINTERBOTTOM, E. J., L.D.S. 16, Sloane Street. (C. 1865-66.)
	1863	WINTERBOTTOM, E. J., Jun., M.R.C.S. & L.D.S. 16, Sloane Street.
	1856	WOODHOUSE, ALFRED J., L.D.S. 1, Hanover Square. (C. 1867.)
	1866	WOODHOUSE, W. H. 1, Hanover Square.
	1859	WOOLFRYES, HENRY A., L.D.S. 1, Gloucester Street, Portman Square.
	1867	WRIGHT, F. 4, Westbourne Park.
Madras	1862	CLARKE, SMOLLETT W.
	1862	PORTEUS, H. W., M.D. (*Honorary.*)

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	Elected	
MADRID	1867	COOPAT, E. A. L. 10, Piazza Principe Alfonso.
MAIDENHEAD ...	1866	LUKE, JAMES, F.R.C.S.Eng. Maidenhead Thicket. (*Honorary.*)
	1859	GHRIMES, S. Belmont, and Nice. (*Honorary.*)
MALTA	1865	YEO, MATTHEW COLE. 32, Strada Reale, Valetta.
MALVERN.....	1863	WILLIAMS, E.
MANCHESTER ...	1856	BROOKHOUSE, ROBERT, L.D.S. 323, Oxford Road. (C. 1859-60, V.P. 1861-62-63.)
	1862	CAMPION, H., M.R.C.S.Eng. 226, Oxford Road.
	1860	ROGERS, SIMON ALFRED, L.D.S. 19, St. John's Street, Deansgate.
	1864	SMALE, H. C., L.D.S. 59, Piccadilly.
	1858	SMITH, GEORGE W., M.R.C.S.Eng. & L.D.S. 6, Aytoun Street.
NEWARK	1867	KING, R. F. H. Appleton Gate.
NEWBURY	1856	ROGERS, CHARLES DEEBLE, L. D. S. (C. 1863-64-65.)
NEWCASTLE-ON-TYNE...	1863	NIGHTINGALE, D. T. 9, New Bridge Street.
NEW ZEALAND...	1867	COOK, AUGUSTUS. Princes Street, Auckland.
NORTHAMPTON...	1863	WILKINS, B. St. Giles's Square.
NORWICH.....	1863	BOULGER, P. J. 64, St. Giles's Street.
	1857	BRIDGMAN, W. K., L.D.S. 69, St. Giles's Street. (C. 1861-62, V.P. 1863-64-65.)
	1856	WHITE, RICHARD, L.D.S. St. Giles's Street. (C. 1862-63.)

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	Elected	
NOTTINGHAM ...	1859	HEPBURN, DUNCAN DEWAR, L. D. S. Regent Street. (C. 1862-63.)
OXFORD	1862	VIRGIN, H. J., L.D.S. 63, High Street.
PAISLEY	1863	CAMERON, T. R. 33, Gauze Street.
PARIS	1861	BYGRAVE, CHARLES. 3, Rue Laffitte.
	1864	DIDSBURY, J. M., L.D.S. 10, Rue de la Paix.
	1859	EVANS, THOMAS WILLIAM. 15, Rue de la Paix. (*Corresponding.*)
PENZANCE	1860	MAGOR, MARTIN, L.D.S. 24, Chapel Street.
PETERBORO'.....	1859	PALMER, JAMES EDWIN. Priestgate.
PLYMOUTH	1861	BALKWILL, F. H., L.D.S. 143, Union Street.
	1856	BATE, CHARLES SPENCE, F.R.S., L.D.S. 8, Mulgrave Place. (C. 1859, V.P. 1862-63-64.)
	1857	COLES, STRATTON JAMES. 3, Princes Square.
	1857	JEWERS, FREDERICK ARTHUR. 4, Flora Place, Union Road.
	1862	MOORE, W. V., L.D.S. 15, Princes Square.
	1860	TUBBS, C. F. 4, Athenæum Terrace.
PORTSMOUTH ...	1856	MARTIN, JOHN, F.L.S., L.D.S. Cambridge House. (C. 1858, V.P. 1859-60-61.)
	1862	MARTIN, J. H. C., M.D., M.R.C.S.Eng., & L.D.S. Cambridge House.
PRESTON	1864	COX, EDWIN, L.D.S. 51, Fishergate.
	1859	KYAN, JOHN HOWARD, L.D.S. Fishergate.
	1863	ROWE, H. R., L.D.S. 60, Fishergate.
RAMSGATE	1859	ROBERTS, C. D., L.D.S. Memel House. (C. 1867.)

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	Elected	
READING	1864	PETTY, F., L.D.S. 1, Wilberforce Place.
RICHMOND	1863	HEATH, T. W. 8, The Green.
ROCHESTER	1863	ROBERTSON, J., L.D.S. St. Margaret's Bank.
ROME	1859	BURRIDGE, LEVI SPEAR, M.D., D.D.S. 5, Piazza di Spagna. (*Corresponding.*)
SHEFFIELD	1863	MOSELY, GILLAM, L.D.S. 205, Bath Buildings.
SHREWSBURY ...	1866	JONES, HORATIO M. 3, St. John's Hill.
	1864	NIGHTINGALE, C. G., L.D.S. Castle Street.
SOUTHAMPTON ...	1863	PAYNE, J. P. 2, Sussex Place.
SOUTHSEA	1863	FORWARD, R., L.D.S. 11, King's Terrace.
	1862	WHEELER, J. C. Fitzclarence House.
ST. LEONARDS ...	1858	RANSOME, ROBERT, L.D.S. 3, Verulam Place. (C. 1867.)
STOCKHOLM	1864	TELLANDER, CARL. (*Corresponding.*)
STRATFORD-ON-AVON ...	1863	GAMBLE, J. G.
SWANSEA	1857	SCOTT, FREDERICK JAMES CLOUSTON, L.D.S. 9, Fisher Street.
SWITZERLAND ...	1860	KOLLIKER, PAUL ALFRED. 12, Stadelhofen, Zurich. (*Corresponding.*)
TORQUAY	1856	RODWAY, HENRY BARRON. Park Place.
	1860	RODWAY, C. A., L.D.S. Park Place.
TRURO	1865	TUCK, W. R., L.D.S.
WINDSOR	1864	MOORE, E. 18, Thames Street.
WOLVERHAMPTON	1865	DE LESSERT, ALF. ALEX. 10, Waterloo Road.

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	Elected	
Wolverhampton	1858	DE LESSERT, CHARLES GRIERSON, L.D.S. 10, Waterloo Road.
Worcester.....	1865	BARKLEY, W., L.D.S. 47, Foregate Street.
	1867	SYLVESTER, G. I. 57, Tything.
Yeovil.....	1861	HUNT, W., L.D.S. Pen Villa. (C. 1864-65-66.)
York	1861	CUSSONS, GEORGE. 33, Coney Street.
	1856	KING, JOSEPH, L.D.S. 33, Coney Street. (C. 1866-67.)

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GENERAL MONTHLY MEETING.

Monday, November 6, 1865.

THOS. A. ROGERS, Esq., President, in the Chair.

The following Gentleman was duly elected a Member of the Society :—

William Richards Tuck, L.D.S., Truro, Cornwall.

The following Gentlemen were proposed for the Membership of the Society :—

Mr. A. P. Reboul, L.D.S., Resident.
Mr. W. H. Woodhouse, Resident.
Mr. W. Robertson, Birmingham, Honorary.

The following Donations were made to the Museum and Library :—

By Mr. Vidler,—Portion of a lower jaw from the ruins of Pompeii.

By Mr. Evans,—"Quelques Détails sur l'Introduction de Caoutchouc Vulcanite," and "La Commission Salutaire des Etats Unis."

Dr. Beigel produced some preparations which he thought would be of interest to the Society. They were obtained whilst he was engaged in investigating the microscopical structure and chemical composition of different parts of the human frame. The tooth, as they knew, was composed of ivory, cementum, enamel, and a thin membrane—first shown by Nasmyth and by Kölliker—called the "Cuticle of the enamel." He was not aware that either of those parts had been obtained separately; the part preserving its natural shape. He obtained the preparations, consisting of the distinct parts of the tooth, in their several natural shapes, by boiling the tooth in different acids. If the tooth was boiled in dilute sulphuric acid, the ivory and cementum were destroyed, but not the enamel; and if the operation was continued long enough, they would obtain (No. I.) the enamel in the shape of a little horse-shoe. No. II. shows a similar preparation, within which just so much of the ivory was preserved as to form the walls of the pulp cavity. By boiling a tooth in nitric acid, all the parts were destroyed equally. Then they were enabled to destroy the enamel and the cementum, and to retain the

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ivory, as shown in No. V. Another preparation showed the enamel, the cementum, and the nerve. These experiments might, he hoped, be made practically useful; and suggested that the enamel-cap might be used as a covering for artificial teeth, so that they might not be distinguished from the natural teeth. Another interesting result was that the experiments proved that there exists not only a difference in the microscopical structure of the different parts of the teeth, but also in their chemical composition, because the parts were acted upon in different degrees by different acids. His experiments were not completed, but he hoped, at some future time, to obtain separately the very thin cuticle of the cuticulum. If pure sulphuric acid was used, then the destruction of the tooth was too rapid; by mixing the acid with an equal part of water, its action could be more easily controlled.

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The President (Mr. Thos. A. Rogers) read the following Paper—

On Fang-Filling.

A tooth derives its vitality and nutriment from two sources—the pulp, and the peridental membrane. The pulp is the remains of the organ from which the dentine is formed, and contains numerous vessels and nerves; from it prolongations pass into the tubuli of the dentine, conveying nutriment and, doubtless, nervous agency of some kind throughout the bony tissue. The peridental membrane is derived from the alveolar periosteum; it is a fibrous membrane, closely investing the fangs of the teeth, and from it vessels pass into the cementum of the fangs, when that substance is present in any quantity. I have heard it said that the teeth are nourished by the pulp, and that they keep up their connection with the rest of the system by means of the peridental membrane. This assertion might seem to be supported by the fact that, although the pulp may be destroyed and the tooth still remain a comparatively healthy part of the organism, yet if the external membranes perish, the tooth almost always becomes a source of disease and distress to its owner. But it seems difficult to dissociate and distinguish between the two functions so decidedly: the nutrition of a tissue indicates its connection with the rest of the

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system, and its connection with the system includes its nutrition.

Undoubtedly a tooth is in a better condition when both its sources of supply are acting, as a limb is healthier when its circulation is carried on by the main trunk and the collateral branches than when the main trunk is obliterated. The reason why the tooth can dispense with the pulp more readily than with the external membranes is, that the destruction of the former does not bring a diseased surface into direct contact with the surrounding tissues; whilst disease of the latter communicates the malady to the neighbouring parts, and involves the destruction of the pulp in its progress; but these effects are owing to the different position of the organs, not to any difference in their function.

A curious fact is reported by Dr. Taylor, in the "Dental News Letter" for January, 1856. He says—"We have the reported case of Dr. Mussey, alluded to some year or two since, in which, on the removal of an inferior incisor, the labial portion of which, and also the point of the fang, was laid bare by an absorption of the gum and alveolus, and yet the pulp was alive. The nerves and blood-vessels which pass in and out at the apex of the root had been severed by the disease for some time; still, blood and a living nerve were found in its narrow canal. During the summer" (I am still continuing the quotation), "having

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occasion to remove two such teeth for a patient, we split both for an examination, and found in one a living nerve, and blood-vessels apparently perfect."

It seems rather a truism to say that here, where no parts were left adjoining the membranes which had perished, the loss of the peridental membrane set up no disease in them; but what seems to me is, that the condition of things arrived at resembled that of the loss of the pulp in so far that no direct contact of diseased with healthy organs was established, and therefore no irritation was set up, and a collateral circulation was established between the remaining healthy external membrane and the pulp. In a conversation with Mr. Tomes on this subject, he informed me that he has occasionally seen vessels pass through the side of the fang into the pulp, about midway between the enamel and the apex. This would account for what I have alluded to as the collateral circulation; but still I look upon these cases as, to some extent, evidence that the assumed difference of function of the pulp and peridental membrane is apparent only. It is true that no reason is assigned for the extraction of these teeth, but it is easy to understand that they were the cause of mechanical irritation to the gums and lip.

Another proof of the identity in function of the organs is, that they are supplied by branches of the same vessels and nerves. From this it also

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occurs that the shock to the external membranes when the pulp is destroyed is very great, and may be followed by results fatal to the success of the operation, either by the amount of congestion and inflammation set up, the vessels to the external membranes being at first gorged with the blood which should have passed into the pulp; or by the irritation communicated to the other terminal filaments of the wounded nerve.

The operation of extirpating the pulp and filling the fangs of teeth may be divided into three stages:

I. The destruction and removal of the pulp.

II. The stage between the extirpation of the pulp and filling the fangs.

III. The operation of filling the fangs.

I.—*The Destruction and Removal of the Pulp.*

The modes of destroying the vitality of the pulp at our disposal are twofold—mechanical and chemical; either by at once plunging an instrument into the organ and breaking it up, or by applying caustic preparations to it, until it is devitalized by their agency. A combination of these plans will be found preferable. The first, though perhaps (in simple cases, at all events) the least likely to be followed by failure, is sometimes very difficult, owing to the firm adhesion of the living pulp to the walls of the pulp cavity, and is always so extremely painful that few persons care

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to submit to it. The second, though far less severe, is liable to be attended with unfavourable results, at all events if the entire pulp is so destroyed. Arsenious acid is our specific in this operation, and a most effectual one it is; but its well-known absorbability checks our free use of it. We probably all of us know but too well how liable teeth, in which it has been largely used, are to inflammation at the root, and destruction of the peridental membrane afterwards. This being the case, the best plan is to devitalize the body of the pulp and some length of the fibre in the canal of the fang with arsenic, and then to destroy the remainder at the same time that we remove the whole organ by means of the instruments for that purpose.

But there are several things to be considered in respect to the best methods of employing our resources.

1. The placing the tooth in the best condition for the proper action of the arsenic.

2. The best form of arsenical preparation; and—

3. The time it should be allowed to remain in the tooth.

1. *The placing the Tooth in the best Condition for the Proper Action of the Arsenic.*—The pulp should be exposed as largely as possible. This is a great point, because the destruction can then be effected more rapidly than if only a small portion

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be exposed, and because it can be effected with less pain. The action of arsenic is accompanied by inflammation; one of the symptoms of inflammation is swelling; consequently the larger the opening made for the pulp to swell through, the less will be its pressure against its unyielding walls in all other directions, and the less the accompanying pain. Moreover, the larger the orifice into the pulp cavity, the more easy will the operation of removing the pulp be, and the less will be the pain when the act of extirpation is performed, because more room is made for the displacement of the pulp, and the compression of the organ is not so great when the instrument is passed into it.

I would remark that if, in excavating a cavity, there is reason to apprehend the exposure of the pulp, it is better to remove as much of the decay as possible, and to open out the cavity well, before working in the direction of the nerve.

It is generally considered that there is a probability of greater pain if the arsenic is applied in the afternoon than in the morning. If this be so, I presume it to be due to the tendency to exacerbations of febrile excitement and nervous pain which occur late in the day.

I have also frequently observed that whereas arsenic sets up pain when applied to a quiescent tooth, it generally stops it if the tooth is already aching. In the former case inflammation is set up; in the latter the inflamed surface is rapidly

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destroyed, and so the pain is, temporarily at least, relieved.

2. *The Best Form of Arsenical Preparation.*—Many preparations of arsenic have been recommended. At first arsenious acid alone—the common white arsenic, in powder—was used in doses of about $\frac{1}{15}$ gr. The action of this, however, was rather tardy, and was accompanied by considerable pain.

Dr. Arthur recommended the use of cobalt, which contains arsenic as an impurity. He considered that its insolubility in this form lessened the danger of absorption. My own experience is not favourable to its use; its action on the nerve seems exceedingly slight.

The formula I now employ, and which I believe to be the one in ordinary use, is—

> Arsenious acid, 3 parts;
> Sulphate or acetate of morphia, 2 parts; and
> Creasote, sufficient to form a thick creamy paste.

The morphia is supposed to lessen the pain (though some not only doubt this, but even aver that it tends to increase the suffering, by primarily stimulating the part); the creasote both diminishes the pain and, by dissolving the arsenic, brings it into more intimate and speedy contact with the substance of the pulp.*

* Since bringing forward the subject of fang-filling, I have seen a communication by Mr. Waite in the "Dental Journal," No. 114, as-

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A subject of some interest for consideration is whether the preparations of arsenic used by Dentists deteriorate by keeping. A small quantity of the formula I have mentioned above lasts a long while, and it is much more convenient, and saves a great deal of our time when it is most valuable, to have our preparations ready for use, than to be obliged to compound them at the moment. I am assured by chemists that no deterioration does take place. It is, however, necessary that the preparation should not be dry; it should be of a creamy consistency, else it does not act so readily. In applying the arsenic, a small quantity should be taken up on the point of an excavator, and gently placed on the exposed pulp, so as to cover every part of it. If the cavity is deep enough, a small gold cap should then be placed over it, so that the temporary filling should not press upon it. By observing this little precaution much pain may be avoided, as the pulp has thus room to swell when the inflammation comes on.

It occasionally happens, especially on the side of a tooth, that there is not sufficient depth of cavity to retain a temporary filling of wool and mastic, or of wax. In such cases I have found the osteo-plastic stoppings useful. In these

serting the insolubility of arsenious acid in creasote. After careful inquiry, I find this to be true, and that arsenic does not dissolve in creasote. The best solvent for arsenic I am told is glycerine.

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shallow cavities we cannot, however, employ the cap.

3. *The Length of Time the Arsenic should be allowed to remain in the Tooth.*—On this point the testimony of different writers varies much. Some maintain that a few hours—eight or even fewer—will be sufficient; others, that two or three months will not be too long for a single application to be left in a tooth. (Westcott, "Dental Cosmos," vol. ii. p. 119.)

Here, as usual, a middle course is best. The arsenic need only be allowed to remain for a few hours, but it is not always advisable to commence operations directly it is removed. Its action continues for some time after its application has ceased; and a good general rule is to leave it in the tooth for forty-eight hours with a feeble delicate patient, or in a transparent white tooth, and for seventy-two or ninety-six hours in opaque yellow teeth, and with strong robust persons. It may then be removed, and, if the patient cannot bear the operation immediately, creasote applied daily for from a week to a fortnight before removing the pulp.

The uncertainty on this subject may be partly due to the more or less perfect contact of the arsenic with the pulp. By thoroughly pasting it over all the exposed portion, and carefully covering it with a cap, there is less fear of pushing it

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away from its proper place in inserting the temporary filling.

We occasionally meet with a very troublesome condition of the pulp. In spite of several applications of arsenic, it continues excessively sensitive, even more so, perhaps, than when it was first exposed. I have sometimes found that this sensitiveness is superficial; and that, after the first entrance of the instrument, the pain of passing it through the rest of the pulp is comparatively trifling; but more commonly in these cases the patient cannot bear this, and we must desist; the only plan, unless the patient will submit to the pain of the instant removal of the pulp, is, according to my experience, to continue the use of creasote until the tenderness subsides; but I have known ten months to elapse before this came to pass.

I do not know to what this condition of things is owing, and trust it may receive some elucidation from the experience of others in the discussion this evening. I have heard it ascribed to the presence of secondary dentine; and Dr. Maynard, of Washington, a great authority in all matters relating to this operation, considers that it is due to the compression of the semifluid matter of the pulp; and finds that by freely opening into the cavity, and then drawing the pulp down piecemeal, without pressing the instrument far up at any one time, it may be diminished.

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It ordinarily happens that on first removing the temporary filling, the exposed surface is extremely sensitive to the touch of the instrument; but this excessive tenderness is greatly lessened by a few minutes' exposure to air, and does not appear to be of the same obstinate nature as that which I have just alluded to.

As soon as the exposed portion of the pulp is sufficiently callous, and before proceeding to remove that organ, it is better still further to prepare the cavity of decay, so that there may be as little mechanical irritation as possible after the extirpation of the pulp. At this stage, however, the simple (or external) cavity only can be treated; the pulp must be removed before the cavity which contains it, and the cavity of decay can be thoroughly united to form a well-shaped "compound cavity." Bold treatment is very necessary here. An amount of cutting away that would not be justifiable in ordinary operations, is not only justifiable, but imperative in these. The less the distance between the external orifice and the orifice of the entrance into the canal of the fang, the better will be our work in the fang; and on the distal surfaces of the back teeth, especially those of the lower jaw, it is almost impossible to reach the canal without giving the surface a very slanting direction by free filing. In forming the simple cavity, however, it is always necessary to bear in mind what its relations will be with the

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pulp cavity in the particular case under treatment. Two irregularly formed cavities will have so to be united as to form one well-shaped one for the reception of the filling. For example, to take two extreme cases, the external walls of the cavity may be so broken down by decay that it becomes advisable to cut down the side of the tooth almost to the level of the pulp cavity, so as to make that cavity, when enlarged, the only one to be filled; or the decay may have worked through to the pulp with but comparatively little lateral extension, so that the pulp cavity will have to be enlarged to form straightsided walls with the external one. In the first example no countersinking should be given at this time, as that will have to be done, if any should be needed, where the pulp now lies, and the whole of what would otherwise be the external cavity may be swept away; in the latter all the countersinking may be done now, as we are working on what will still be the external wall of the compound cavity. These varieties in the conduct of the operation must, of course, be left to individual judgment; it would be almost impossible to describe every feature which may present itself, and all operators differ somewhat in their modes of treating the same case.

It seems to be the proper place here to consider whether or not it be absolutely necessary to destroy and remove the pulp up to the very apex of the fang.

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Dr. Maynard considers it so important to do so, that, in order to be certain of its accomplishment, he passes a finely barbed instrument *through* the foramen. He then rotates the weapon gently, and draws it slightly back, so that he feels the *outer* rim of the foramen all round. If any attempt at all be made to destroy the nerve, I consider it necessary to destroy it entirely. In operations which I performed some years since to a considerable extent, and do occasionally perform now, with the view of preserving the exposed pulp, I found that the slightest irritation—even that of having lessened the sensitiveness of the dentine *before* the pulp was exposed—was sufficient to diminish the chances of success considerably; and if we excise the nerve at any point short of the end of the fang, it simply becomes a question of what is the difference between a nerve exposed and filled over in the crown and one so treated in the fang of a tooth. Unless a deposition of bone takes place, covering the exposed part, failure would result in either case; and although an *uninjured* pulp may, and sometimes does, take on ossific action, yet I doubt very much whether a nerve irritated by the excision of the greater part of its substance would have any tendency to do so, and, if not, it would be sure to perish; and of course, if any dead animal matter be left in the fang, its decomposition will give rise to such irritation of the peridental membrane as will most

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probably result in the failure of the operation. But if we examine carefully the structure of the tooth at the apex, we shall find a slight constriction of the canal just within the foramen, and at this point the dentine ceases and the cementum begins to form the wall of the pulp cavity, so that *practically* this is the end of the canal. In some cases even, according to Dr. White ("Dental Cosmos," vol. ii. p. 193), the cementum dips into the canal and lines it for a little distance. Moreover, we must all have noticed that, in forcing a probe into the cavity of decay and up the nerve canal of a living tooth just extracted, small spots of blood appear at points in the neighbourhood of the foramen as well as through the foramen itself. These circumstances all point to a high condition of vascularity, and consequently of vitality, of that part; and it has always appeared to me advisable to avoid infringing upon it, for that reason. Doubtless it is very difficult to regulate the operation to such a nicety as to say for certain that the pulp shall be extirpated up to an exact spot and no further, but practically our instruments decide the point for us. The same instrument is generally used to remove the pulp that completes its destruction, and the barb on the weapon offers an impediment to its progress beyond the constriction near the apex.

As regards the actual extraction of the nerve, an instrument delicately barbed is passed rapidly

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but steadily through the body of the organ, and as high up the fang as it will go without difficulty. It should not be pushed up with a jerk, both on account of the greater pain so caused and the greater danger of laceration of the soft parts, by which they would have to be removed piecemeal. It should next be rotated two or three times, so as to excise the nerve, and then gently withdrawn. The rotations should all be made in the same direction, by which the nerve-filament generally becomes slightly twisted round the instrument, and is the more readily brought away. In withdrawing the weapon, the point of the barb should be pressed against one wall of the canal—against the narrowest side, if one side be narrower than another—as the instrument thus occupies a diagonal position, and opposes a larger surface to the matter to be removed. There is usually, of course, some amount of pain attending this operation; and even when the death of the pulp has been effected so high that there is no pain in the excision, there is generally a sharp twinge when it is withdrawn, owing, probably, to the exhaustion of the air in the canal.

We shall occasionally meet with deposits of secondary dentine sufficient to cause obstruction to the instrument. The only plan, in such cases, is to open out the cavity as freely as possible to the seat of the obstruction, and then to endeavour to remove it; but we shall not always

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be successful, and must make the best compromise we can.

Twice in my practice I have broken off my instrument when rotating it, and have failed to get the piece out. In both cases I filled over it. In the first the tooth was soon lost from periosteal inflammation. The same result threatened in the second, which occurred about a year and a half ago, but it was averted by leeching and hot fomentations.

II.—*The Stage between the Extirpation of the Pulp and Filling the Fangs.*

Authorities differ very much as to the propriety of proceeding to fill the fangs directly after the removal of the pulp, or of waiting to allow the irritation caused by that operation to subside. One practitioner—Dr. Pease—has the gold ready, and the mouth prepared for the filling, before he extracts the nerve; and the instant he has removed it he passes the gold up the canal. I would recommend a careful perusal of his paper in the "Dental Cosmos" for August, 1862, and will merely observe that he prefers to remove the pulp after a line of demarcation has formed between the dead and living parts, so that no hæmorrhage takes place. Mr. Tomes, also fills the fang immediately, and finds this plan to possess a marked advantage over the other. He attributes the favourable result to the "perfect obstruction to

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the ingress of oral fluids, and the prevention of the accumulation of more than a very minute amount of coagulum." ("A System of Dental Surgery," p. 416.)

Dr. J. D. White ("Dental Cosmos," vol. i. p. 169) does not consider this sound practice, because of the fact that every wound bleeds for a certain length of time, and after that there is effusion of coagulable lymph, and which may be more than can occupy the space between the plug in the root and the fragment of blood-vessels and nerves left in the apex. Dr. Harris ("Dental Cosmos," vol. i. p. 647) says that many operators too hastily fill the pulp cavity before the vessels at the foramen are perfectly healed. As a consequence, serum is poured out, and inflammation of the peridental membrane is the result. He is therefore in the habit of keeping the tooth under treatment several days preparatory to filling.

The question seems to turn upon whether the wound caused by excising the pulp heals by the first intention or by granulation. If the whole organ is destroyed by caustics the latter is the process set up, and it is then undoubtedly better to wait till it is completed before inserting the gold. But when the nerve is living and healthy at the point of excision, the wound being so small, it is reasonable to expect that in a healthy subject it will heal by the first intention, and this result will be greatly facilitated by the exclusion of air.

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Mr. Tomes observes on this point that "the consequences which follow the laceration of a soft tissue will, *cæteris paribus*, generally be proportioned to the amount of surface injured. In the case of a tooth, the sectional area of the pulp near the end of the root is so small that its division in a healthy subject will not be followed by inflammation, unless the injured part is subsequently exposed to irritation. But should the saliva find access, or a large coagulum collect in the vacant cavity or in the interstices of the wool, and decompose, the lacerated surface will become inflamed, and the disease will extend from the remnant of pulp to the periosteum of the root and socket." ("Dental Surgery," p. 416.)

If there has been no pain in excising the pulp, and there is no bleeding afterwards, I do not proceed to fill directly, but push a piece of wool, twisted into a strip and soaked in creasote, up the fang, in such a way that I can remove it easily when I wish. I then plug the cavity of decay with wool and thick mastic, and change the whole every day for about a week. I next insert a temporary gutta-percha stopping, and, if that gives rise to no discomfort for about a fortnight, I fill with gold, judging that length of time sufficient to show the condition of parts about the apex of the fang. If the nerve is living at the point of excision, I wait till the bleeding has ceased before filling, but prefer to insert the

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stopping at the same sitting, and as soon as possible.

Before commencing the stopping I finish the formation of the cavity, taking care in so doing to give free access to the canals. It is also necessary to enlarge the coronal end, and some little distance of the proximal termination of the canals, so that there may be a free passage for the gold. The best instrument for this purpose is a long spear-headed rose-drill. A rose-drill does not jar the tooth so much as an ordinary drill would; and it brings the chips away in its depressions. The whole cavity being thoroughly dried out, I now proceed to the third stage of the operation; but before quitting this part of our subject I may allude slightly to those cases where death and disorganization of the pulp have already occurred, with irritation at the root of the tooth, and gum-boils. It is sometimes important that teeth, even when they have arrived at this stage, should be preserved; but the results of efforts for the attainment of this object are so uncertain, that, except in cases of the greatest importance, I do not advise the patient to submit to the necessary treatment.

The plan I am in the habit of pursuing in such cases is, the daily syringing of the root with warm water, and the application of wool, soaked in creasote or iodine, up the canal, at the same time painting the gum, if it is very red, with a mild

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solution of nitrate of silver (four grains to the ounce), taking all possible care to confine the applications to the affected part, so as to avoid unpleasant stains, which are difficult of removal. Unless some improvement is manifested in a few days, I syringe the canal with creasote or a solution of iodine (℞ Iodinii gr. viij, Potassii Iodid. gr. xvj, Aq. destillat. ℥j) in addition to the above treatment. If undue pressure is exercised by an antagonistic tooth, either that or the tooth under treatment should be filed, so as to prevent the antagonism, and the patient's attention should be directed to the care of the general health. This treatment may extend over months; and even where it has been perfectly successful, and the tooth has been filled, there is always a tendency to the occurrence of gum-boil on slight provocation, such as cold or such derangement of the general health as we are always liable to. I have, not unfrequently, filled the fangs of teeth which were giving rise to gum-boils without any preparatory treatment, and often with success; but I do not know the laws which regulate the success or failure of such operations.

I am glad that great attention is now being paid to the subject of alveolar abscess, which has hitherto been much neglected, though the frequent occurrence of that affection makes it a very important subject for our study.

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III.—*The Operation of Filling the Fangs.*

If, after extirpating the nerve, the cavity of decay only were filled, a vacant space would be left between the filling and the apex of the fang; and this, after a time, would become occupied by fetid animal matter, or by a peculiarly offensive effluvium, either of which might give rise to inflammation of the peridental membranes. These emanations arise either from the contents of the tubuli of the dentine (which are scarcely likely to be removed with the pulp), or they are the product of irritation of the parts about the foramen; and the chances of failure from either cause will be diminished by carrying the filling as high as possible up the fangs, since the walls of the canal are then lined, and the escape or reflux into the canal of the contents of the tubuli prevented, and the risk of inflammation at the apex lessened by the exclusion of all but a very minute quantity of air.

Before describing the operation of filling the fangs it may not be useless to devote a few moments to the examination of the shape of the canals in the different teeth.

As a general rule, these follow the outlines of their respective fangs, whether those be flattened, as in the upper bicuspids and anterior fang of the lower molars; rounded, as in the upper lateral incisors and lingual fang of the upper molars; or oval, as in the canines and lower incisors.

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In the upper front incisors the canals are either round or flattened from side to side; in the upper laterals they are round or slightly oval; in the upper canines oval. In all these teeth (especially, perhaps in the lateral incisors) the canal curves somewhat towards the mesial line, as it forms the cavity in the crown of the tooth.

In the upper bicuspids the cavity is at first flattened in the labio-lingual direction; it then almost always bifurcates, whether there be two fangs or not. In the second bicuspid, and sometimes in the first, when the fangs do not separate, the canals reunite towards the apex. The fangs of these teeth are often very fine towards their extremity, and not infrequently make one or two abrupt curves.

Of the upper molars, the internal or palatal fang is the largest; it is rounded or slightly flattened in the antero-posterior direction; it leaves the crown of the tooth at an obtuse angle, and is either straight to the end or slightly recurved. The external fangs are flattened transversely; the anterior larger than the posterior, and generally more curved than it, the curvature inclining backwards towards the posterior. The same description applies to the canals.

The canals of the lower incisors and canines are somewhat oval, the labial extremity being broader than the lingual. Those of the canines are the largest, and of the lateral incisors generally

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the smallest. They are oval also in the bicuspids, the labial extremity being broadest in the first, the lingual in the second. In the latter the canal is often constricted in the middle, and broader at its labial and lingual extremities.

In the lower molars both fangs are flattened transversely; their general tendency is to slope backwards. The canal of the posterior is larger and more rounded than that of the anterior; that of the anterior flattened, and expanding at both extremities.

I feel sure that I have noticed a disposition in old teeth to lose, to some extent, the characteristic form of their canals; and that as these become smaller they also acquire a generally rounder shape.

The most difficult fangs to fill are the buccal fangs of the upper molars, the anterior fang of the lower molars, and the fang of the second lower bicuspid. They should be opened up as much as possible by drills, but I am constantly unable to make a perfect filling in them. (I seldom make the attempt in the upper molars.) Fortunately, their small size, whilst it adds so much to the difficulty, at the same time diminishes the risk of failure of the operation.

In filling the fangs we have to consider the materials and the instruments.

Gold, osteo-plastic, even wool with creasote, have all been employed; and Dentists of good

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repute aver that they are more successful with the latter method than with any other. I have not tried it as a permanent filling, though constantly as a temporary one; but if, as I consider, the object be to prevent the reflux of decomposing animal matter from the tubuli into the canal, I can scarcely think that wool and creasote, however tightly packed, would answer the purpose.

Osteo-plastic has also been employed by eminent practitioners, and I have tried it in a few cases of great difficulty within the last six months. Hitherto all have been successful, but time enough has not yet elapsed to prove the efficiency of this plan. It is a most inconvenient preparation to use for this purpose, and I doubt whether, if my fillings were examined, it would be found to have passed very high up the canals. In a case which occurred about two years ago, that of a very young patient, scarcely twelve years old; having reason to apprehend that development was still continuing at the apex of the fang, I employed gutta percha, on the principle that its presence would be less offensive than gold to parts in such an excitable condition. The child died a few months afterwards from an attack of scarlet fever, so that the result of such a mode of treatment has yet to be ascertained. Gutta percha is, however, a good temporary stopping.*

* After I had commenced writing this paper, I tried gutta percha for filling the fangs in some cases, viz. 3, 11, 15; but sufficient time

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Gold, in the form of foil, is the material I almost always employ. I specify foil, because I have tried—and probably others have also done so, if they would not mind confessing it—wire, of pure soft gold, for the purpose. The objection to this is, that if it be not a tight fit, space is left between it and the sides of the canal; and if it be, it seems to compress the air behind it in forcing it up the canal, and so gives rise to irritation. This plan certainly has not been successful in my experience, nor have I obtained better results from a somewhat analogous plan—that of using foil twisted into a tight coil. In fact, the only failure I am aware of within the last two years and a half occurred in a case treated in this manner, though I must say that I was not sanguine of success in this instance for other reasons.

In using foil, it is better to employ a thick number, say No. 8 (I use Abbey's, of Philadelphia, whose gold contains the number of grains per sheet that the figure indicates), which is not liable to tear easily; and to cut it into narrow short strips about one-third of an inch long; narrow, of course, to allow it to pass freely up the canal; and short, that the end may not become entangled with the surrounding parts or sides of the tooth, or be so heavy as in the upper teeth to fall back on the instrument when packing.

has not yet elapsed to enable me to speak with confidence as to the result.

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Cylinders of gold are sometimes recommended, but I do not think it makes much difference whether cylinders or strips are used. In examining fillings made after either plan, I have found sometimes the cylinders compressed one above the other, as strips would have been, and sometimes the strips pierced and pressed eccentrically, like cylinders.

The instruments must necessarily be very fine, but they should be strong and firm towards the hand, else power is lost, and they are apt to spring as they pass up the canal. The stronger the instrument can be made, consistently with its delicacy, the more smoothly it carries up the gold before it. That for the extremity of the fang must be very fine and flexible, so as to stand bending to reach the point of operations. I have tried the plan of splitting the end of it, placing one extremity of the strip of gold in the notch, with the view of carrying it to its place more effectually. But besides the difficulty—I might say the impossibility—of so treating a sufficiently fine instrument, a fatal objection is, that when it has passed as high up as it will go, the gold is tightly held by the compression of the weapon against the walls of the canal, and cannot be deposited in its place.

The instruments for the coronal half or third of the canal should be stronger, harder, and of definite shape, as compression exercised even two-

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thirds down the fang will materially condense the gold at the apex.

In the act of carrying the gold to the apex we should choose for its passage the broad side of the canal, if there be one. Thus, the anterior in the canines and lower incisors, labial in the first lower bicuspids, and lingual in the second. The gold should be carried forwards gently, and as smoothly as possible up the canal, till it meets with some resistance; and then a slight vibratory movement may be employed, till the gold refuses to pass higher. If the proximal end of the strip be still in sight, a good plan, before withdrawing the instrument, is (if the nature of the operation allows of a second plugger being held in the left hand) to press the second plugger against the visible end of the gold, enabling it to resist the retrahent action of the first instrument. Then a fresh portion of the strip should be caught and carried up till all is used, and a fresh strip taken.

I have tried the plan of leaving the proximal end of the first strip, and carrying up a second by the side of it, and a third, if possible, before condensing the proximal ends of any of the strips; but the difficulty of the operation is increased in the smaller canals. The advantage I thought to gain was that of a smoother and more continuous lining to the walls of the canal.

As soon as the gold gets within reach of stronger pluggers, it should be well condensed,

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and larger strips of foil employed for the rest of the operation, which thenceforward partakes of the nature of an ordinary filling. In the canal of a large tooth, such as a canine, a sheet and a half, and even more, of No. 8 gold, may easily be used up by the time the plug is level with the floor of the cavity of decay. When the plug has reached this point, it is usual to polish its surface before proceeding to fill that cavity. I do not see the necessity for so doing; on the contrary, I prefer to leave it rough, so as to secure a more intimate union with the next piece of gold.

The following are the results of seventeen cases :—

Case I.—Mr. M——; about 25 years of age; middle height; fair complexion; health delicate; teeth altogether in a bad state.—Has had the right upper first bicuspid removed lately on account of pain, which, however, still continues; apparently in the second bicuspid, which has a large amalgam plug in it; the left upper bicuspids are also largely filled with amalgam.

1864, *June 7th.*—Right upper second bicuspid, anterior approximal surface; removed the amalgam plug, and applied arsenical paste (arsenious acid, acetate of morphia, and creasote).

June 21st. — Removed pulp with considerable pain; filled fang and crown.

Quite successful when last seen in May, 1865.

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CASE II.—*Same patient.*

1864, *August* 19*th.*—Left upper second bicuspid, anterior approximal surface.—The amalgam came out a few days since, leaving an extensively decayed cavity, impossible to excavate without exposing the pulp; having done so, I applied the arsenical paste.

August 20*th.*—Removed the pulp, and completed the operation. There was considerable pain a few days afterwards, but which was relieved by leeching.

Quite successful in May, 1865.

CASE III.—*Same patient.*

1864, *August* 20*th.*—Left upper first bicuspid; posterior approximal surface. — The amalgam dropped out whilst I was filling the adjacent tooth (Case II.). The gum has been the seat of constant gum-boils ever since the tooth was filled. The pulp is dead, of course. I carefully removed all animal matter from the root, and applied German creasote, with directions to continue its application till both Mr. M—— and I had returned from our holiday.

October 26*th.*—Mr. M—— returned to me to-day. The gum better, though still unhealthy; but as the tooth is rapidly crumbling away, I must not delay operating. I have no great hope of succeeding here, but we occasionally get unexpectedly favourable results from similar "given up" cases;—prepared the cavity, and inserted a temporary filling of wool and mastic with creasote.

November 9*th.*—The temporary plug has remained in the fang, but that in the cavity of decay pressed against the gums, and irritated it so much that Mr. M—— removed it. Filled fang and cavity with Hill's stopping.

The tooth continues comfortable; the gum healthier, though with occasional gum-boils.

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Case IV.—Miss E——; age 21; tall; dark complexion; thin.

1864, *August 22nd.*—Right upper first bicuspid.—The tooth much broken away; pulp not actually exposed, but implicated in the decay, and certain to be laid bare in excavating, which I therefore did immediately; applied arsenic, and also on the 23rd, 24th, 25th, and 26th. Pulp still very sensitive, but as Miss E—— is on the point of marriage, I removed it on the 27th, and filled the fangs, and on the 30th filled the crown with gold.

Quite successful to the present time.

Case V.—Mrs. M. L——; age about 25; scrofulous. —The teeth generally are breaking away and decaying, in spite of previous good fillings; the decay is white, pulpy, and unhealthy. The patient is having a family quickly, and is delicate, but is very anxious to preserve her teeth at all hazards.

1864, *August 25th.*—Right upper lateral incisor; has been plugged on both sides, and is dead; gum-boils existed previous to the loss of the fillings, but have subsided since that happened. Thoroughly cleaned both cavities, and found them to join. Removed a quantity of fetid matter from the canal, prepared for filling, and inserted creasote dressing, which was renewed on the 26th and 27th.

August 29th.—Filled the fang with gold, and the crown with osteo-plastic. The gum-boil still remains in the same condition as before the operation; but I have completed the operation, as the patient is leaving town. I have not heard of the case since.

Case VI.—Mrs. S. S——; about 30 years of age; middle height; dark; good constitution.

1864, *September 29th.*—The front teeth good, but the back teeth almost all decayed; the left upper second molar is a mere dead shell; the left upper first bicuspid

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nearly as bad; frequent pain all along that side of the mouth. Left upper first bicuspid, extensively decayed—the diseased bone "cheesy"; the point of exposure of the pulp clearly marked by a whitish oozing; very sensitive to touch: applied arsenic.

October 10th and 17th.—Fresh arsenical applications; the tooth still remains sensitive, but after removing the greater portion of the decay, I found the pulp considerably deadened: destroyed and removed the pulp, and filled the fangs.

October 24th.—No trouble since the last visit; filled the crown with gold.

Quite successful in March, 1866.

Case VII.—Mr. G——; age 19; tall; dark.—Right upper second bicuspid; anterior approximal surface; has been previously filled with gold (by me), but fresh decay has occurred under the gum, and has caused great pain.

1864, *October 18th.*—Applied tannin and eau de Cologne on wool to relieve the pain.

October 20th.—Removed the filling. The dentine excessively sensitive, but the pulp much less sensitive than the dentine covering it. Removed the pulp, and filled the fang.

October 26th.—Quite comfortable. The cavity being very irregular in shape, and shallow from the amount of cutting away, I filled with osteo-plastic.

1865, *November 10th.*—Removed the osteo-plastic filling, and inserted a gold plug.

1866, *March 5th.*—Going on well.

Case VIII.—Mr. H——; age about 37; middle height; fair.—Right upper second molar; has been filled (by me) some time since; about a month ago, pain came on, relieved by leeching, but the tooth has continued very tender ever since.

1864, *October 28th.*—Removed plug; exposed and re-

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moved the pulp from the internal fang, and filled with gold. Remains of the pulp still existing at the extremity of the external fangs; applied creasote.

November 4th.—Great tenderness of the tooth, and inability to retain the dressing on account of the pain; applied arsenic.

November 10th.—Still tender, though less so. Mr. H—— is suffering from a severe domestic affliction, and will be unable to continue his visits; I therefore inserted a temporary plug of Hill's stopping. I have seen the patient since, but omitted to note down the state of the tooth at the time.

Case IX.—Mr. S——; age 65; middle height; spare; care-worn.—Left lower first bicuspid; posterior approximal surface.

The tooth broke away some time ago, leaving a wide saucer-shaped cavity; pulp all but bare. An awkward case, as, owing to the loss of the second bicuspid, this tooth falls backwards in the mouth. So many teeth have already been lost that it was resolved to attempt to save this.

1864, *November 2nd.*—Found the pulp nearly dead; removed it, and filled the fang, but was obliged to use a piece of gold twisted into the form of a wire for the purpose, as I could not work with strips, owing to the inclination backwards of the tooth.

November 19th.—Extracted the tooth, on account of peridental inflammation, after leeching and fomentations. On post-mortem examination, I found the canal filled for about two-thirds of its length, but loosely, and surrounded with pus and blood.

Case X.—Mrs. W——; about 33 years of age; short; spare; dark.—Left upper first bicuspid.

1864, *November 10th.*—Had been plugged, but the stopping had fallen out, great part of the tooth having

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broken away; pulp cavity exposed, but no trace of the pulp till the probe is passed high into the fangs; creasote dressing daily.

November 21*st.*—Removed the remains of the pulp with but little pain, and filled the fangs.

November 26*th.*—No pain; filled the crown with osteoplastic.

Case XI.—Captain d'E——; age about 40; middle height; thin; dark.—Right lower second bicuspid; has been plugged with amalgam, which also occupied the space between the teeth, resting against the molar. Lately, there have been several sudden, smart shocks in that direction, occurring at varying intervals, without any apparent cause, and the patient cured them for a time by cramming wool and mastic between the teeth, and all round the amalgam as far as possible.

1864, *November* 16*th.*—Removed the amalgam, and found the pulp dead. Capt. d'E—— leaves town next week, so I filled the fangs and crown temporarily with Hill's stopping.

November 18*th.*—Called again with a return—though comparatively slight—of the same sensations, again relieved by thrusting wool and mastic between the teeth. Removed a sunken amalgam plug from the anterior approximal surface of the first molar. Excavated the cavity anew and refilled.

April, 1865.—The patient so comfortable, that he declines to have the temporary plug in the bicuspid removed.

Case XII.—Miss J. S——; age 17; tall; fair; inclined to be stout.—The teeth have been badly treated. The right upper canine has been filled on its anterior approximal surface with gutta percha after the application of arsenic. The filling is quite loose. Pulp not actually exposed; but evidently in an unhealthy condition.

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1864, *November* 22*nd.*—Removed the pulp, which was dead. Pressed a small piece of wool, soaked in German creasote up to the end of the canal, and filled over it with gold. The cavity being very large and visible, the patient preferred osteo-plastic to gold for the crown filling.

Successful up to the present time.

Case XIII.—*Same patient.*—Right upper lateral incisor; had been filled, but very badly, and fresh decay is going on. Removed the plug and found fresh decay in every direction. The pulp is not actually exposed, but is so close to the cavity of decay, that it is laid bare immediately.

1864, *December* 3*rd.*—Applied arsenic.

December 5*th.*—Destroyed and removed pulp, and filled fang and crown. There being some tenderness after the operation, I ordered leeches.

December 9*th.*—The tooth has been painful; the gum over it and the canine is very red. To use fomentations of poppies and chamomiles.

December 10*th.*—The tooth still painful and the gum red. Painted the gum with nitrate of silver.

December 12*th.*—All pain and redness gone.

December 13*th.*—The mouth is quite comfortable.

Successful at present time.

Case XIV.—Miss A. S——, sister of the last patient; short; inclined to be stout; about 18 years of age.—Right upper canine; had decayed without much pain; the pulp actually bare.

1864, *December* 1*st.*—Applied arsenic.

December 6*th.*—Removed the pulp. Filled the fang and crown.

December 9th.—The tooth has been tender, and was relieved by the application of a roasted fig.

December 13*th.*—Quite comfortable.

Successful at present time.

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CASE XV.—Miss E——; age 14; tall; dark.—Right upper second bicuspid. Posterior approximal surface.

1865, *February 4th.*—Very much decayed. Has never been attended to. The pulp exposed directly. As she is going to school, I extirpated it at once. The canal was very large, and the instrument apparently passed through the foramen. Filled with Hill's stopping.

April 24th.—A little pain followed the operation, but subsided without any treatment. As all is now quiet, and Miss E—— again returns to school to-morrow, I decide on not interfering with the temporary plug.

CASE XVI.—Miss J——; age about 25; short; thin; fair; in delicate health.—Left lower bicuspid; has not been previously attended to. The pulp is exposed and very sensitive.

1865, *March 3rd.*—Applied arsenic.

March 4th.—Removed part of pulp; very painful. Fresh application of arsenic.

March 7th.—Removed the rest of the pulp with considerable pain. Filled the fang.

March 21st.—The ceiling of the cavity has broken away since Miss J——'s last visit. Filled the crown with Palladium amalgam.

I believe this case is going on well.

CASE XVII.—Mr. R. W——; about 20; tall; thin; fair.—Right lower first bicuspid; has been previously filled by me. Fresh decay has occurred, and caused the loss of the plug. The patient has kept the cavity filled with wool and mastic for about a month.

1865, *March 3rd.*—Applied arsenic.

I have no further notes of this case; but I removed the pulp soon after the last date, and filled the fang and crown.

1866, *January 19th.*—Quite successful at present time.

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GENERAL MONTHLY MEETING.

Monday, December 4, 1865.

THOS. A. ROGERS, Esq., President, in the Chair.

The following Gentleman was proposed for the Membership of the Society :—

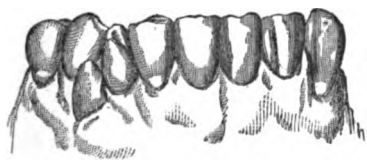
Mr. H. L. Vanderpant.

The following Donations were made to the Museum :—

Mr. H. E. Sewell. Model of an upper jaw, showing two supernumerary teeth amongst the incisors.

Mr. Thos. A. Rogers. Model of an under jaw, showing three supernumerary teeth in the place of the right canine (fig. A.), the two

fig. A.



innermost teeth appeared to be united, while the external one was separate from the rest. The patient was a man of about 40 years of age.

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ANNUAL GENERAL MEETING.

Monday, January 8, 1866.

THOMAS A. ROGERS, Esq., President, in the Chair.

The following Gentlemen were duly elected Members of the Society:—

Mr. William Henry Woodhouse, 1, Hanover Square, W. (Resident.)
Mr. Anthony Percy Reboul, L.D.S., 1, Albert Street, Islington, N. (Resident.)
Mr. W. Robertson, The Square, Birmingham. (Honorary.)

The following Gentleman was proposed for the Membership of the Society:—

Mr. Henry E. Sewill, L.D.S. (Resident.)

The following Gentlemen were elected as Officers and Council for the year 1866:—

President.—W. A. N. Cattlin, Esq.

Vice-Presidents.—W. Imrie, Esq.; W. Perkins, Esq.; G. A. Ibbetson, Esq.; James Parkinson, Esq.; H. J. Barrett, Esq. Non-Resident:—S. Tibbs, Esq. (Cheltenham); Dr. Roberts (Edinburgh); R. H. Moore, Esq. (Dublin); C. Bromley, Esq. (Southampton).

Treasurer.—Arnold Rogers, Esq.

Librarian.—J. B. Fletcher, Esq.

Honorary Secretaries.—J. Drew, Esq.; C. Rogers, Esq.; Foreign.—Thomas Underwood, Esq.

Council.—H. T. Kempton, Esq.; R. T. Hulme, Esq.; G. Owen, Esq.; A. Hill, Esq.; S. Cartwright, Esq.; E. J. Winterbottom, Esq.; J. Saunders, Esq.; F. Weiss, Esq.; R. Hepburn, Esq.; W. A. Harrison, Esq.; J. Tomes, Esq. Non-Resident:—S. L. Rymer, Esq. (Croydon); W. Hunt, Esq. (Yeovil); J. A. Baker, Esq. (Dublin); T. R. M. English, Esq. (Birmingham); J. King, Esq. (York); N. King, Esq. (Exeter).

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The following Donations were made to the Museum :—

By Dr. Carpenter, of Croydon.—A pair of ancient forceps.

Dr. Levison.—The skull of a sturgeon.

Mr. Statham.—A lower molar with three fangs.

Mr. Tomes.—Models of upper and lower jaws, Plate A, representing most remarkable instances of exostosis of the alveolar portions of those bones. The casts were taken from a gentleman of about forty, who had resided for many years in Bombay, and who, on coming to England, sought to obtain the use of artificial teeth, his own teeth, as he said, having become loose. He eventually went to Mr. Canton, in St. Martin's Lane, at whose suggestion he consulted Mr. Tomes, by whom the casts were taken. The enlargement was strictly confined to the alveolar portion of both upper and lower jaws. The finger could be passed on the upper jaw back to a considerable extent, so as to reach to the base of the nose, and also behind the projections in the palate. The base of the lower jaw was of the usual size, whilst the alveolar portion projected very considerably both anteriorly and posteriorly. He suffered no inconvenience till lately, and now only because the teeth were getting loose. Some ten or fifteen years ago he had a portion clipped off, from the anterior part of the upper jaw, and nearly lost his life from bleeding, hence would not submit to a repetition of the operation. Not less interesting than the case itself is the fact that the son of the patient has jaws in precisely the same condition. He is now under treatment by Professor Syme, of Edinburgh.

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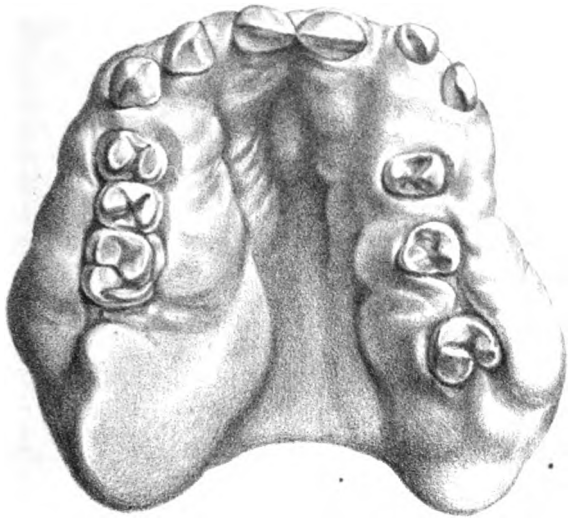

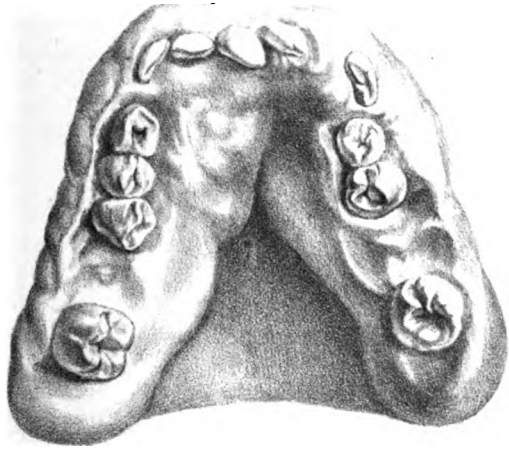

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GENERAL MONTHLY MEETING.

Monday, February 5, 1866.

W. A. N. CATTLIN, Esq., President, in the Chair.

The following Gentleman was duly elected a Member of the Society:—

Mr. H. L. Vanderpant, 52, Maddox Street.

The following Gentlemen were proposed for the Membership of the Society:—

Dr. Frederick Werner, M.D., and D.D.S. by exam. (Corresponding).

Mr. Emile Martin Evrard Schultze (Non-Resident).

Mr. R. Hepburn exhibited a new form of blow-pipe invented by Mr. Kirkwood, of St. James's Square, Edinburgh.

Mr. Patrick exhibited a new form of Vulcanizer.

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Dr. Richardson read a paper on

A New Method of Producing Local Anæsthesia applicable to Dental Surgery.

The process for producing local anæsthesia, which I have the honour to present to the Odontological Society, may be called in short "*The Process for producing Anæsthesia by a Narcotic Spray*," and the instrument I shall place on the table may be called "*The Anæsthetic Spray Producer.*"

The principle of the process is a combination of extreme cold with a volatile anæsthetic fluid.

The action of the process in a physiological point of view is very simple. In the first instance the spray, from the extreme degree of cold it causes, acts by extracting force from the part of the body to which it is applied, and afterwards, when the nervous filaments of the part are exposed, by preventing the conveyance of force through the nerves. Sensation is the conveyance of force or motion from the extreme parts to the brain. The motion is communicated by the blood in the form of heat: it is communicated to the nervous filaments, and by them is conveyed to the sensorium. This is passive sensibility. When we irritate a nervous fibre, as by a cut, we communicate more motion rapidly along that fibre and cause pain. This is active or exalted sensibility. To remove sensibility, therefore, we must adopt one

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of three processes: we must remove or render inert the sensorium; we must stop the evolution of force generally by arresting oxidation of blood; or we must rob the body locally of its force beyond that with which it is constantly being renewed. We see the first of these processes in action in cases of pressure on the brain, as from injury or effusion of blood; we see the second whenever we produce general anæsthesia by charging the blood with chloroform or other analogous anæsthetic; and we see the third when, by means of extreme cold, we rob the local part of the force that has been brought to it by the blood.

The fact that cold applied locally to any part of the body removes the sensibility of the part, has been known for ages; but it remained for my valued friend, Dr. James Arnott, to demonstrate that cold might be turned to account in surgical operations, and to invent a means of application by the ice and salt bag.

Some years ago I brought out a mode of producing local anæsthesia by combining the external application of narcotic solutions with a continuous galvanic current. Practically, this plan, though in some cases singularly successful, turned out useless; but the inquiry it called forth had the advantage of making me think more deeply on the principles that ought to be held in view in obtaining a ready and efficient local anæsthetic. The result of my labours led me to believe that Dr.

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Arnott's process was the soundest basis of operation, and that if it could be applied in combination with a narcotic, the object in view would be secured.

On this theory I invented various plans for insuring the combination of cold with a narcotic. At one time I tried to freeze parts with ice and salt, and then to inject narcotics beneath the frozen structure by the hypodermic method. I could, however, discover no satisfactory plan until a new line of thought was suggested to me in the spray apparatus, or atomizer of liquids.

The Anæsthetic Spray Producer.—When the toy for diffusing eau de Cologne in fine vapour over the skin, in the form of spray—which some time ago found its way into our drawing-rooms—first came before me, it struck me at once that it might possibly be applied to the production of local anæsthesia; and I set to work to try its applicability in this respect. I first used Matthesien's spray apparatus, employing compressed carbonic acid as the force for diffusion of external spray, but the process was too cumbersome. I was soon afterwards assisted largely in my labours by taking advantage of Siegle's apparatus, with the hand-ball bellows invented by my friend Dr. Andrew Clarke, and supplied by the manufacturers, Messrs. Krohne & Sesemann, of Whitechapel Road.

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With this apparatus I set myself to determine the degree of cold that could be produced by the vaporisation of all the known volatile liquids, and I determined the fact that the intensity of the cold produced held a definite relationship to the boiling-point of the fluid used; the rule being that the lower the boiling-point the greater was the amount of cold exhibited. In these inquiries I employed a very delicate thermometer, directing the spray upon the bulb from half an inch to an inch and a half from the point of the jet. By these means I learnt that with rectified sulphuric ether I could bring down the thermometer within 10 degrees Fahr. of zero, and that by directing the jet on the skin I could produce a certain definite and marked degree of local insensibility, but not sufficient for surgical purposes.

I next got Mr. Krohne to construct for me a hollow cylinder of thin metal, six inches long and three inches in diameter. In the circumference of this cylinder was a chamber one eighth of an inch in diameter for containing ether. The ether communicated with a tube which was joined to an air-tube, as in Siegle's apparatus, and the centre of the cylinder was filled with ice and salt mixture. In this way the ether was reduced to zero, and when vaporised, gave spray which brought down the thermometer six degrees below zero, and produced on the skin such entire insensibility that I could pass a needle through the part without sensation.

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I afterwards got Mr. Krohne to make me a double spiral apparatus, the one spiral for holding ether, the other for the transmission of air, and the whole inclosed in a reservoir for ice and salt. This instrument proved disadvantageous in practice for three reasons: — 1. That it was cumbersome. 2. That it implied on every occasion the production of a freezing mixture. 3. That owing to the extreme cold, the water vapour in the air in its transit through the air-tube condensed into ice and blocked up the jet.

[Dr. Richardson, in relating the above facts, placed all the instruments referred to before the Society, and explained the action of each.]

To succeed it was necessary therefore to dispense with the freezing mixture altogether.

In considering how this object could be achieved, it occurred to me that if a larger body of ether than is supplied by Siegle's apparatus could be brought through the same jet, by mechanical force, in the same interval of time, and with the same volume of air, a proportionate increase of cold must necessarily be produced. The theory was one of pure physics, admitting even of arithmetical demonstration, and running parallel with the lessons which had been taught me with respect to the cold produced by liquids having different degrees of boiling-point. The theory was put to the test at once, and proved correct to the letter. By driving over the ether under atmospheric

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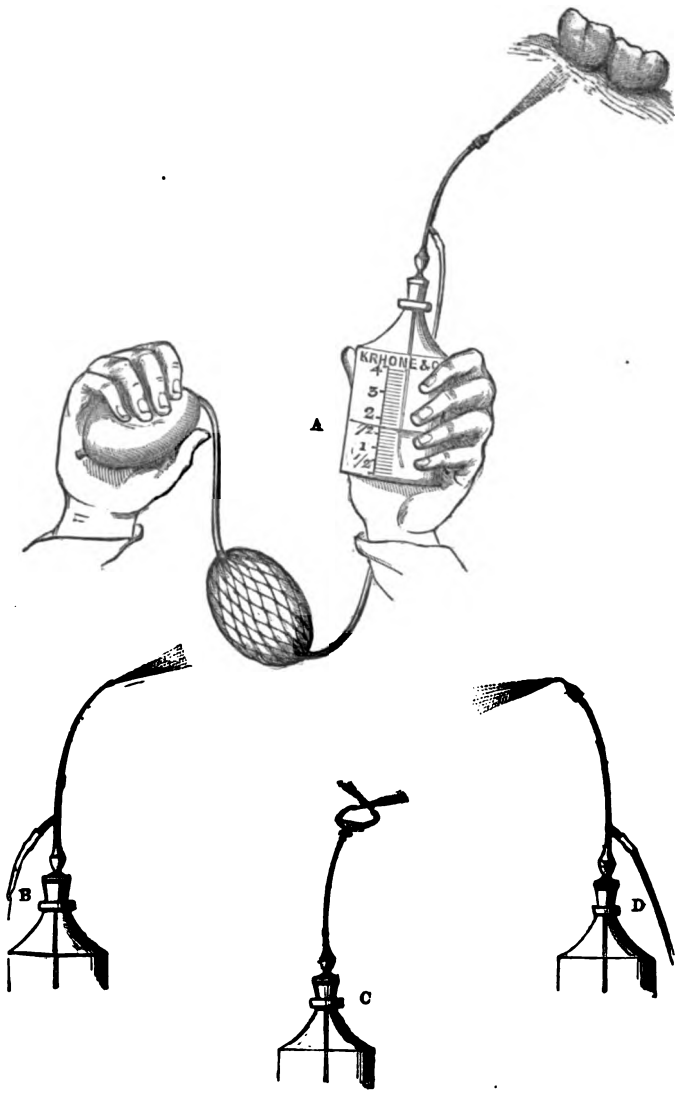

A.—*Anæsthetic spray apparatus in action with ordinary jet.*
B.—*The same with probe jet.*
C.—*The same with cross jet.*
D.—*The same with small curved jet.*

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pressure, instead of trusting simply to capillary action—or to suction, as in Siegle's apparatus—the spray evolved brought the thermometer within thirty seconds to four degrees below zero—the result that was desired. On this I instructed Messrs. Krohne & Sesemann to construct the simple apparatus depicted here.

The apparatus consists simply of a graduated bottle for holding ether; through a perforated cork a double tube is inserted, one extremity of the inner part of which goes to the bottom of the bottle. Above the cork a little tube, connected with a hand-bellows, pierces the outer part of the double tube, and communicates by means of the outer part, through a small aperture, with the interior of the bottle. The inner tube for delivering the ether runs upwards nearly to the extremity of the outer tube. Now, when the bellows are worked, a double current of air is produced, one current descending and pressing upon the ether, forcing it along the inner tube, and the other ascending through the outer tube, and playing upon the column of ether as it escapes through the fine jet. By having a series of jets to fit on the lower part of the inner tube, the volume of ether can be moderated at pleasure; and by having a double tube for the admission of air, and two pairs of hand bellows, the volume of ether and of air can be equally increased with pleasure, and with the production of a degree of cold six degrees below zero.

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With this simple apparatus, at any temperature of the day, and at any season, the surgeon has in his hands a means for producing cold even six degrees below zero; and by directing the spray upon a half-inch test-tube containing water, he can produce a column of ice in two minutes at most, as I now proceed to show.

[Dr. Richardson here directed the spray on a thermometer bulb, with the effect of bringing the mercury to zero. He then froze water in a half-inch test-tube, and sent it round amongst the members.]

When the ether spray thus produced is directed upon the outer skin, the skin is rendered insensible within a minute; but the effects do not end here. So soon as the skin is divided, the ether continues to exert its action on the nervous filaments; so that the narcotism can be extended very deeply, indeed to any desired extent. Pure rectified ether used in this manner is entirely negative; it causes no irritation, and may be applied to a deep wound, as I shall show, without any danger.

APPLICATION OF THE PROCESS IN PRACTICE.

For all superficial operations on the skin this method of producing local anæsthesia offers everything that can be desired. Further, the ether being quite innocuous, it admits of being applied to an incised wound, and so the narcotism may be carried

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to a considerable depth. In one of my first trials, Mr. Wm. Adams made into the thigh an incision an inch and a half deep, and five inches long, after I had narcotized by this method, the patient being absolutely unconscious of pain.

I shall not trouble the Society further with the details of general operations, but shall pass at once to the application of the process for operations on the teeth.

OPERATIONS ON THE TEETH.

The first time the process was applied at all was in a case of tooth extraction on the 11th of December, 1865. The instrument used was one in which the ether was exposed to freezing mixture before being distributed in the atomized form.

The patient was a lady, who required to have five front teeth extracted. I had previously administered chloroform to this lady for a tooth extraction, but the inhalation had produced so much irregularity in the action of the heart and other disagreeable symptoms, that I considered it unadvisable to repeat chloroform, and she herself was only too ready to give the local measure a trial. The extraction was performed by my friend Mr. Peter Matthews. On directing the ether spray first at a distance, and then closely upon the gum over the first central incisor on the left side, we

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observed, at the end of fifty seconds, that the gum had become as white as the tooth itself, and quite insensible. I then directed the vapour upon the tooth for twenty or thirty seconds more, and on the patient intimating that she did not feel, I suggested to Mr. Matthews to proceed. He extracted a very firm tooth without the slightest expression of pain. The process being continued in the same manner, he extracted three other teeth with the forceps. The fourth tooth gave way, and had to be removed by the lever; but in all cases the result was equally good. Not a drop of blood was lost; there was no painful reaction; and the healing process proceeded perfectly. Our patient, who was exceedingly intelligent, was specially requested to note every step of the operation, such as the applying of the forceps, the insertion of the blades beneath the gum, the loosening process, and the removal. She told us that in two of the extractions she felt nothing; that in one it seemed as though the jaw altogether were being pulled downwards, but without pain; that in another she was conscious of a kind of wrench or loosening, but without pain, and that the introduction of the lever was attended with a momentary dull ache, just perceptible. On the whole, the process was quite as painless as when she took chloroform.

On December 13th I applied the local anæsthetic to the same lady for the further extraction of nine

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teeth, Mr. Peter Matthews again operating. The results were equally good with the first seven, at which point, unfortunately, the apparatus partly ceased play. At the eighth tooth pain was felt, and at the ninth, the apparatus being out of play, the operation caused great pain. We regretted this much, although it gave us the information of the perfect action of the process when no mechanical obstacle interfered with it. The reason why the apparatus stopped play was very singular, and could hardly have been foreseen. It arose from the condensation of water derived from the air in the air tube, and from the blocking up of the fine jet with a little portion of ice.

With the apparatus made on my new plan, I have had several tooth operations. On the 24th of January of this year my friend and neighbour, Dr. Sedgewick, extracted a very difficult left upper canine from a lady after I had produced the local insensibility. Not the slightest consciousness of pain was exhibited or felt. On the 29th of the same month Dr. Sedgewick removed from the upper jaw of the same lady three other very firm teeth with the same results.

I applied the anæsthetic on Saturday, February 3rd, to five patients, while Mr. Gregson operated for extraction. The cases were all for extraction in the lower jaw except one.

The first case was that of a female; the tooth to be extracted was the right bicuspid in the upper

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jaw. The tooth was so disorganized that extraction was difficult, and had to be performed by two operations. The patient from the first was extremely nervous, rendering the application of the anæsthetic very difficult. She reported afterwards that the ether produced no pain, and that the first grip of the forceps was painless; that the first extraction was almost painless; but that the second caused acute pain, especially at the root of the tooth.

In the next case, in a man aged 37, the first lower molar of the right side was extracted. The fangs of the tooth were separated, and Mr. Gregson removed the posterior fang first, and the anterior fang afterwards. The patient said the ether caused no pain; that with the first fang he felt pain low down, but was not conscious of the application of the forceps; the second stump was very painful (the elevator was used). The man observed, on his own account, that his jaw "was benumbed."

The next case was one of extraction of the first lower right molar tooth. The tooth, Mr. Gregson thinks, was as difficult as any that he ever removed. The man expressed pain, but he afterwards said that the pain was less than in the extracting of two loose teeth which had been removed previously.

The fourth case was that of a very nervous girl, 14 years old; the tooth was the first molar on the

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left side. She screamed before she was touched, and continued to utter a cry of nervous fear throughout the whole of the operation. Good anæsthesia was, however, produced, and the tooth was readily extracted. Afterwards the girl declared persistently that she felt the tooth drop out, but experienced no pain whatever. This case was one in which the evidence of the patient was perhaps doubtful, owing to her youth and the nervous excitement she exhibited.

The last case was that of a woman 24 years of age. The tooth was the left wisdom tooth on the lower jaw. The tooth was very firm, but the patient was calm, and submitted intelligently to the process. I was therefore able to narcotize completely, with the result of an entirely painless extraction. The patient did not make a single movement during the operation, and afterwards stated that she was not conscious of anything except that the tooth, as she expressed it, "dropped out."

From all these experiences we gather clearly as a fact that by the process I have described extraction of teeth may be performed absolutely without pain. Such failures as occurred were simply due to faults in carrying out the details. These will be removed by experience, and by improved apparatus.

I have already succeeded in obviating many of

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these difficulties. The first step in this direction has consisted in making a spray-producer with a double jet. By this means the spray can be directed on each side of the tooth and gums at one and the same time.

MODE OF APPLICATION.

The process is much more easily applied to the upper than to the lower teeth, because in the case of the lower teeth the ether accumulates between the jaw and the cheek. To meet this the space should be neatly padded with sponge or with cotton wool, so as to take up the ether. The spray should be directed at the lower part of the tooth over the gum; it should be directed slowly at first, so as to accustom the patient to the cold, then sharply. It is not necessary to extend the application beyond a minute.

The ether must be absolutely pure, having a boiling-point not above 94° Fahr. Methylated ether does not answer: it causes pain and much after-irritation. Chloroform is objectionable for the same reasons.

It should be remembered that the narcotism produced is very transient, so that the operation must be done quickly.

There is no danger of sloughing from reaction.

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ADVANTAGES OF THE PROCESS.

The new process is an improvement on the freezing mixture of ice and salt, in that it is more easily applied, and is immediately at hand at all seasons of the year.

Compared with chloroform, I find the new process already advantageous. In a large experience with chloroform from the first days of its use, I discover, on analysis of my cases, that in one case out of five, patients have experienced pain from tooth extraction, even when chloroform was administered, while the dangers and difficulties were very great. The fact is, in applying chloroform in dental practice, it is essential to operate during the first or the fourth stage of narcotism. In the first stage the patient is partly conscious, and can assist the operator by obeying his directions, but is always conscious of pain, and restless. In the second and third stages the masseter muscle is invariably firmly contracted, and there is difficulty in opening the jaw. In the fourth stage there is complete relaxation, and no pain, but the danger is invariably extreme, and such as is never necessary in cutting operations in other parts of the body, because they can always be performed in the second or third stages. Hence the difficulty and extreme danger of applying chloroform in tooth extraction.

In 1859, to avoid these difficulties, I invented

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the nostril plan of exhibiting chloroform, by making the patient inhale from a Snow's inhaler through one or both nostrils, and I once succeeded by this means in keeping a patient insensible for forty minutes, while Mr. Spencer Wells removed half the lower jaw from a patient of Mr. Hulme's. I found that by this process I could produce the most rapid narcotism that I had ever seen, and that I could profoundly narcotize in four minutes with from half a drachm to a drachm of chloroform. In one case, indeed, I narcotized with fifteen minims of the vapour. I regret that the extreme danger of this process has led me reluctantly to abandon it, because the only case of extreme danger that I have encountered, and in which death nearly occurred, was produced by this method, less than a drachm of chloroform having been used.

The danger lies in the rapidity of the narcotism. The patient forgetting to breathe by the mouth, takes in at once from ten to twelve per cent. of chloroform vapour, and the heart is suddenly paralyzed. Except, therefore, in operations for removal of the jaw,—where I would first narcotize in the ordinary way and afterwards use a single nostril tube to keep up the effect,—I will never again apply chloroform by the nostril process, and I predict that were this process ever largely carried out it would necessarily lead to many fatal catastrophes.

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As the originator of the nostril process of chloroform administration in dental surgery, I feel great relief in having the opportunity of making this public retractation before the Odontological Society of Great Britain.

The new process of local anæsthesia which I have the honour to describe to-night, is on the whole quite as effective as chloroform, while it avoids every danger; and although I do not profess that it is perfect in its details, I am convinced as to the soundness of the principle, and I trust unhesitatingly to time and experience to remove all the difficulties that at present stand in the way.

Dr. Richardson (at a subsequent meeting) remarked, that instead of having the loose double jet, which he originally constructed, he had introduced a jet, which he believed dentists now used, with the two points fixed to the instrument. He preferred the fixed jet to the loose jet, in consequence of the stability of the ether current which was obtained. There was no exuding of the ether at the points where the connection was made, and although the points did not admit of being turned round so readily, yet there was a great advantage in having a steady jet. The objection was that for upper and lower teeth, it was advisable to have different tubes; but that objection would obtain with regard to forceps or anything else; as for actual perfection, it would be requisite to get

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differently shaped tubes for different teeth. He had previously shown a very fine jet which fitted on to the end of the tube, and which he called originally a jet for stumps of teeth. Instead of that jet, he had lately brought out, as much for dental as surgical purposes, a probe jet. For distribution of ether and for perfect action, that, in his opinion, was the best of all fine jets. It yielded less than a minim of ether per second, and the cold was almost immediate when pure ether was used. The operator could modulate the probe jet to any tooth, being able to bend it in the mouth.

As regards the playing of ether upon teeth for dental operations, he had with all front teeth given up the double jet, only using the single probe jet, finding that he could produce with that sufficient anæsthesia for all practical purposes; indeed, such deep insensibility might be produced that he invariably found the fang of the tooth, if he could get it directly the operator had taken it out, intensely cold.

He would add to his observations a little addition he had made for stopping bleeding; and as the plan had been used for the first time on the human subject in a tooth case, it was right that he should refer to it in this Society. It occurred to him that, having a great means of controlling the blood-vessels by means of cold, he might connect with the cold a styptic for blood with great advantage, and in addition a plug. The point was

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to get two substances soluble in ether which would be left behind when the ether evaporated, one of which should be styptic, and the other solid. He had made that solution by taking absolute ether, and then having it treated with xylodine, which was the analogue of gun-cotton, and which was made by the action of nitric acid on starch. The advantage of xylodine over gun-cotton was, that the ether took up a great deal more of it, and it also ran through the spray instrument better. The xylodine having been dissolved in the ether, the ether was treated with tannin in excess, and the solution left for three weeks, by which time as much tannin as possible was taken up, and diffused equally through the ether.

When the styptic solution is made to play upon a bleeding part, in the first place a constringent action is exerted on the blood-vessels from the cold; then the ether evaporates, leaving behind a large mass of tannin, which directly acts upon the blood, and the xylodine is also left behind to form a plug. The xylodine played the part almost of fibrine, and it is remarkable with what ease one could take blood of any character, however fluid, and reduce it to a solid mass. He had some blood with him, drawn from a sheep, defibrinated and allowed to decompose. In that state it was as fluid as port wine; it was very analogous to typhus fever blood, and to that blood which flowed so readily out of the mouth after opera-

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tions in certain abnormal conditions of the blood. If such thin blood were circulating in the body of a person, the merest prick would lead to death from bleeding, unless the flow were rapidly stopped.

He would, however, show them that, by directing his styptic spray even on this blood, he could coagulate it almost instantaneously.

[Dr. Richardson now performed the experiment with entire success. The fluid blood, subjected in a saucer to the spray, coagulated firmly in twenty seconds.]

Dr. Richardson next related that he had had an opportunity of trying the styptic in private practice, in a case in which Mr. Thos. Rogers had drawn a tooth from a subject who, with the whole of his family, was suffering from extreme fluidity of blood. He understood a brother had nearly died from bleeding from a small wound on the hand, while another member of the family had well nigh succumbed from a leech-bite. After Mr. Rogers drew the tooth, there was constant bleeding all night.

On the following morning one of the parents came to him (Dr. Richardson) in great anxiety, and on his visit he found the young man exceedingly languid from loss of blood, and with constant flow from the cavity of a large molar tooth. He first produced an immediate arrest of the hemorrhage by completely freezing the gum, and then in the gentlest manner taking the same jet,

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and putting it into the bottle containing the mixture of ether xylodine and tannin, he directed the spray into the cavity. In a little time the whole of the cavity was filled with the solution, and he found he could build up actually a layer upon a layer of the tannin and the xylodine: at last he filled up the whole space level with the tooth, so that it appeared to the eye like another tooth standing in the place. As the parts relaxed, he saw the blood ooze up. It oozed through the xylodine and the tannin as through a sponge, and then set almost as firmly as another tooth itself. The hemorrhage was entirely stopped, and three days afterwards the plug came away with a perfectly healed surface underneath.

To test the effect of the spray fully, the neck of a sheep about to be killed was cut across, and by spraying with a large spray on the open surface, the whole wound was soon filled with clot, and then taking the clot in his hand, and taking it out, there was no more bleeding, the clot having extended to the vessels: he did not know any bleeding which this contrivance would not, in the course of three or four minutes, actually stop.

On cutting the femoral vessel in an animal, the stoppage of hemorrhage by the styptic is instantaneous: a mere matter of three or four strokes of the bellows is sufficient.

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LOCAL ANÆSTHESIA IN DENTAL OPERATIONS.

There were one or two practical points to which Dr. Richardson wished to speak finally, with reference to the success of local anæsthesia in tooth-extraction. In the first place, in all the operations he had ever performed on the teeth, he had never once had any approach to sloughing. That event had been very much dreaded, but he had no authentic case where it had occurred. The great point to prevent sloughing was to get a rapid anæsthesia. Originally it was thought good practice to produce the whiteness of the surface slowly; but that was a fatal mistake. If the whiteness of the surface could be produced in from thirty seconds to a minute, it mattered not, after the whiteness was produced, how much it was prolonged. If the anæsthesia was very slow and extended over two minutes, owing to any difficulty with regard to the presence of water, or the instrument, or the application of the ether, or the character of the ether, then he could imagine there might be a tendency not to slough but to blister; but in his own experience he had never seen anything of the kind. As a crucial case, last week he had assisted at an operation on the abdomen where the patient was forty-three minutes under the influence of the ether spray, and in that case there was perfect recovery. Also since he met the Society last, he had applied the spray

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over a surface of ten inches for the performance of the great operation of Cæsarian section, and the wound healed by the first intention, and the woman was about her room in twelve days.

There would always be cases in which some sloughing would occur, whether the operation was performed with or without anæsthesia, but as a rule the danger of sloughing was a myth.

With regard to experiments on the surface of the body, they had been carried out to the extent of nearly 4,000 cases, and he had never had a single instance of sloughing. In one instance a peculiar blister formed on the hand of a medical man who was suffering from Bright's disease of the kidney, and that, perhaps, might, under some circumstances, preclude the use of the ether when the disease was known to be present; in another case a gentleman exceedingly subject to a disease of the skin, called herpes zoster, suffered from it after the ether had been applied for the division of a large boil. These two cases deserved notice.

As regarded the success of producing insensibility in the mouth, he found no difficulty in the upper front teeth, and there were certain teeth which one could put one's finger upon, and say the operation was necessarily successful; but as in the back of the mouth, there were more difficulties, although not very many with the upper teeth.

With the lower front teeth the difficulties were

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not very great; but as soon as the canines on either side of the lower jaw were passed, it became difficult to get rid of the saliva. A gentleman from Carlisle, Mr. Kegwick, had recommended the use of sponges which he had tried, but they were rather in the way, and prevented to some extent the action of the ether. A plan had yet to be devised for keeping the mouth dry. The whole secret of the difficulty of producing whiteness in the gums turned on the presence of moisture. It was so on the body, the presence of the water acting in opposition to the ether. A very fine layer of water became frozen, and that prevented the deeper action of the cold. It was not merely the presence of a quantity of saliva which produced the difficulty, but also the fact of the gum being covered with a thin layer of moisture, thereby preventing the action of the ether.

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GENERAL MONTHLY MEETING.

Monday, March 5, 1865.

W. A. N. CATTLIN, Esq., President, in the Chair.

The following Gentleman was duly elected a Member of the Society:—

Henry E. Sewill, L.D.S., 20, Clifton Gardens, Hyde Park.

The following Donation was made to the Library:—

By Mr. Truman.—The Archives of Dentistry.

Mr. Owen brought before the Society an addition to Dr. Richardson's apparatus for producing local anæsthesia, by means of which the ether vapour was driven from the mouth, and the patient relieved from considerable inconvenience. He also produced a vulcanizer, constructed of gun-metal, no iron being used, on the principle of Hayes', with the addition of a lever safety-valve, and also a fusible plug, the former weighted to blow off at 325° and the latter alloyed to become fusible at 340°. He also called attention to the method by which the flasks were kept together, so that there was no expansion during the vulcanizing process.

The Secretary read the following letter from Mr. L. S. Burridge, of Rome:—

"It may be useful to make known a very simple matter which I have found of great importance. I am not aware that it has ever been employed or is even known to any of your honourable body. In case I am mistaken, I beg pardon for troubling you with a twice-told tale.

"The idea is not original with me, and I am seeking no credit, as I have practised the method for the last few months only, and it has succeeded so perfectly, as far as I can judge with this short experience, that I hasten to make it known. If, on further trial, it is found to be objectionable, I shall be as ready to condemn it as I now am to recommend it.

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"The ordinary cavity plate, with its many disadvantages, is of course known to you all, and while with a deep and well-defined arch and firm palate it is almost sure to succeed, so with a low arch, flat and soft palate, it is almost as sure to fail. In the latter cases I have met with most perfect success, by substituting the simple process I shall now endeavour to describe. I have employed it in several cases, but in one instance where I had laboured very hard to make the old system answer without success, I have, with it, obtained all that one could desire, therefore it seems to me very useful. The case in point is so marked, and gave me so much trouble, that I will mention it.

"About two years ago a gentleman applied to me for professional aid, who had lost all the upper teeth; the lower set remaining almost complete. Of course it was desirable, and in fact necessary, to make a set of teeth which would retain their place without springs. And most faithfully did I labour to accomplish the object but could not succeed. He has managed to wear teeth, but they have given him great trouble, by dropping down upon all occasions, much to his mortification and discomfort. He now has a set of teeth which *do not drop*, much to his comfort and my delight. In fact, they remain so firmly in their place that considerable force is required to remove them.

"I hardly know how to describe the simple matter, or what to call it, but as facts are most useful things in this life, I will but state them.

"In the plaster model I cut a groove about as deep as would receive the ordinary gold wire used for pivot teeth—nearly in a circular form, or in shape similar to the old air chamber, making it rather deeper where I found the soft parts in the palate or roof of the mouth most yielding, and on this model made the rubber plate in the usual way, from which process I obtained the desirable results above-mentioned. I feared at first that this narrow ridge would obstruct the circulation in the circumscribed parts, and be the cause of mischief, but it has not caused the slightest inflammation, or even irritation, in any case where I have employed it.

"Unfortunately it could not be used when the palate is hard, unless a soft and yielding spot could be found on either side the medial line, where two or more small rings or chambers could be formed.

"The power given by this method seems to be of a double nature: in the first it raises the mucous membrane like a tent from the surface of the palate, and forms a perfect vacuum; and in the second, the ridge enters so firmly into the soft parts as to keep the piece from sliding or moving from side to side. The process is indeed simple, but the effect I have found wonderful. Its advantages over the old system are many. It strengthens instead of weakening the plate; it occupies no unneces-

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sary space; it does not require the patient to exhaust the air, which, in the old system, is often the cause of a very disagreeable habit.

"In case this plan should prove as useful to any one of your members as it has to me, I beg that he will feel indebted to Dr. G. W. Parmly, of Paris, to whom I am indebted for the idea, and who, I believe, to be the first one who employed it."

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Mr. MUMMERY read a Paper on—

Abnormal Projection of the Incisors and Cuspidati.

THE subject of Dental Irregularity has been so ably treated by several writers, especially by Mr. Tomes, with reference to the causes and general principles of treatment, that any extended remarks by way of introduction would be entirely out of place.

Feeling, however, in common with many of my fellow practitioners, the difficulties which attend the road to entire and permanent success, even when a case has seemed to promise well for a time, I have resolved—at the suggestion of two or three professional friends who had seen some of my models—to bring the subject of abnormal projection of the incisors and cuspidi before our society.

I propose this evening, therefore, almost exclusively to restrict my observations to the difficulties attending the treatment of those cases in which the front teeth of one or both maxillæ project beyond the proper position.

Every one who has treated the cases of this class must have observed how much more easily the teeth can be made to assume a more natural position, than to maintain the improvements beyond the time when the use of the apparatus is discontinued.

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As we often learn quite as much from the failures of others, as we do from their successes, I shall briefly refer to a few of the causes of disappointment, with the ultimate issue of cases to which much attention and thought have been devoted—a condition which is doubtless experienced occasionally by some of my audience.

In the first place I shall refer to the age at which, in my judgment, these cases should be undertaken. I believe that a very large proportion of failures are attributable to the mouth being treated for irregularity before the second permanent molares are erupted. If the first molar is removed before the roots of the second molar are well developed, we usually find that the grinding surface of the latter tooth, when it appears, is found inclined very considerably forward, furnishing a very indifferent masticating organ.

If we remove either of the bicuspides before the second molar has appeared—the *vis a tergo* of the growing tooth inevitably presses the whole series of teeth forward, and the space created by the loss of the bicuspides is occupied by the next posterior tooth, and this, in a large proportion of cases, where a plate is worn with a view to bringing the front teeth inwards.

I therefore would express my belief that the premature treatment of this class of irregularity is a very frequent source of failure.

It is my practice, when an upper tooth takes a

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position within the line of the antagonizing lower teeth (or *vice versâ*, in the case of a lower tooth closing outside the upper teeth), to treat such cases without delay; but in the cases at present under consideration, I have almost invariably found that if, in past years, I have yielded to the importunity of parents, and have undertaken the treatment before the second molars were in place, but little permanent benefit has ensued.

As a general rule I defer commencing treatment until the patient is entering the fifteenth year, that opportunity may be afforded for the natural expansion of the maxillary arch, thus possibly obviating the necessity for sacrificing any of the permanent teeth.

Although the first molares are proportionally more liable to decay than the bicuspides, I much prefer removing one of the latter teeth on each side, carefully selecting the first or second bicuspides, as there may be indications of incipient decay.

I give early attention to the state of the molares with a view to their preservation, and fill with gold any cavity that may exist, at the earliest stage of disease.

I thus secure a firm fulcrum for my plate, by capping one or both pairs of molares, or two molares and two bicuspides.

My usual apparatus is of a construction very familiar to the members of this society—a broad

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well-strengthened gold plate, having strong springs of 16-carat gold-plate, No. 16, and well hammered, soldered upon the lingual side-cappings of the molar teeth, and, as occasion requires, on the outer side also.

In the great majority of cases, I of course recognize the importance of removing a corresponding number of teeth from the lower jaw, and when the lower front teeth strike against the necks of their antagonists, I always take the lower teeth under treatment before the upper; adopting, with slight modifications, a similar apparatus to that already described.

The springs are brought to bear on one pair of teeth at a time, commencing with the bicuspides, and always bearing in mind as my chief object the expansion of the arch in the neighbourhood of the cuspidate and bicuspides.

When we bear in mind, that in order to effect a permanent change in the arrangement of the teeth, the direction and position of the alveoli must be absolutely changed by the gradual absorption of their walls, it will be evident that to insure the steady process of depositing new bone material to build up the altered alveolar processes, we must not attempt to effect such extensive changes as we are considering, by any sudden or violent proceeding.

The elastic springs admit of the most delicate adjustment, and the pressure should be so gra-

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dually increased, that little or no pain is induced; and each pair of teeth in succession may thus be treated, until at last the central incisors are brought into their proper position.

The plate requires to be re-struck to a new model occasionally, and when all the teeth are reduced to a regular position, it is finally re-modelled, and a slighter elastic spring on each side is soldered to the cappings, and accurately adjusted to the labial surfaces of the corrected teeth; they are thus retained in position, and the plate should be laid aside very gradually, continuing its use at night for a period of many months after the treatment is brought to a close.

There are several advantages attending the use of gold plates thus constructed which, in my opinion, render this a preferable method of treatment to certain others which are sometimes adopted.

The plate is easily removed by the patient, yet keeps firmly in its place.

It can thus be cleansed three or four times a-day, and the teeth well brushed, and a great amount of the alleged injury to the teeth is avoided.

Although gold is harder than bone or vulcanite, yet it is not nearly so hard as the enamel, and I firmly believe that the decay on the crowns of teeth when in contact with gold plates (employed either for artificial teeth, or for regulating the

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dentition) is rather attributable to chemical than to mechanical action.

When the patient resides at a distance from the practitioner, this plan enables him to dispense with a considerable proportion of the visits which would otherwise be necessary, without the teeth suffering consequent detriment.

I cannot conclude without referring to one other cause of failure, viz., the want of conscientious perseverance in the use of the apparatus.

I find, however, that when a young lady attains the age at which I prefer to commence my treatment, there is very far less difficulty in prevailing on her to observe prescribed rules, than in the case of a child of ten or eleven years, and we may, in this view of the case, be spared much vexatious experience.

The cases I now submit to your notice have been brought to a successful issue by the plan I have indicated. Some of the models illustrate the evils of premature treatment, and I have selected others in which, after the lapse of periods varying from three to seven years since the completion of the treatment, the teeth still maintain their improved arrangement, without any tendency to deviation.

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GENERAL MONTHLY MEETING.

Monday, April 2, 1866.

W. A. N. CATTLIN, Esq., President, in the Chair.

The following Gentlemen were duly elected Members of the Society:—

Dr. Frederick Werner, M.D., D.D.S., of Giessen, Darmstadt. (Corresponding.)

Mr. E. M. E. Schultz, Calcutta. (Non-resident.)

Mr. S. Amos Kirby brought before the notice of the Society an arrangement for regulating the temperature of any apparatus in which gas was used as the heating medium, and of course valuable for regulating the heat of vulcanizers. He also added to it an arrangement for turning out the gas at the proper time. The apparatus for regulating the supply of gas was exceedingly simple. It consisted of a metallic tube screwed into the cover of the vulcanizer which formed a chamber by having a top screwed into it; this top, which was very thick, was perforated with two small holes which united before they reached the lower side and formed the termination of an inlet and outlet pipe. The chamber was filled with mercury nearly to the point where the two holes united. All metals expand with heat, and mercury expands to a greater degree than any other metal; therefore, as the heat rose in the vulcanizer the mercury in the chamber expanded, and passed into the narrow part which forms the communication between the inlet and outlet gas pipes, partially closing them. The level of the mercury in the chamber could be adjusted to the greatest possible nicety by a small screw on the top, so that the heat at which it would work could be altered at will. If pure mercury was used, its evaporation rather interfered with the steady action of the regulator; but if a very small quantity of tin was added, that quite prevented the evaporation of the mercury. If too much tin was used, it was prejudicial; the tin, being lighter than the mercury, floated on the top, and did not sink with it.

Mr. Kirby further described his apparatus by means of a drawing. In that way, he said, it was quite possible to regulate the supply of gas

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so as to keep the range of heat within 2° or 3°. The first trial he made was for some physiological experiments, in which it was required to keep the substance experimented upon at the temperature of the human body, and by means of a contrivance of that kind he succeeded in keeping it so for some weeks, the only variation being about 1°. In order that the vulcanizing apparatus might be made entirely self-acting, he used in addition to the regulator a common alarum, clock making some alterations in the face by adding a scale outside the usual one, and attaching to the ordinary alarum part an extra hand, arranged so that when it pointed to O on the new scale, the alarum weight would fall and close the gas tap—thus, by setting the new hand at say 1 or 1½ on the new scale, the gas would be turned off in 1 or 1½ hours, as may be required. He used a stop-cock, for regulating the supply of gas to the vulcanizer with a long lever and scale, by which he could put on the exact amount of gas required to get up the heat. He wished to make one or two remarks in reference to vulcanizing apparatus in general. It might not be generally known that there was an exceedingly simple plan of testing steam-boilers—and consequently vulcanizers,—which consisted in filling the boiler quite full of cold water, leaving no room for air under the safety-valve, and weighting the valve considerably above the usual working point, so as to test it beyond the pressure at which you ordinarily work. If gentle heat was then applied to the water it would expand, and should there be any weak place in the vessel it was quite certain that that place would give way, and water escape there; but if the vessel were sound, the water would ooze out of the valve. The suggestion emanated from Dr. Joule, of Manchester, who had taken great trouble to make it public, but unfortunately it hardly seemed to be known at all. The only difficulty in testing a boiler in that way arises from having a leaky safety-valve He noticed it was said at the last meeting that there was occasionally some trouble in getting the safety-valve perfectly steam tight. When first he used a steam vulcanizer he put oil on the valve with the view of making it quite tight, but after a little time found it had a contrary effect, from becoming baked; if the valve was thoroughly well washed with spirits of wine, and ground in slightly with a little fine chalk, there was not the least difficulty in keeping it perfectly tight. The fusible plug, as used generally, was quite insufficient as a safeguard. He did not think if the vulcanizer got to an exploding point, the hole made by the plug would be a sufficient vent for the steam; while, if you had any case that you wished to finish by a stated time, requiring an extra degree of heat, it would be exceedingly inconvenient to have the whole process spoiled by the plug blowing out. It was said that if the steam rose above the temperature at which the plug

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would usually blow out the vulcanite would be spoiled. His experience did not prove that to be the case. By accident, one of his vulcanizers (without a regulator) had the steam at 380° (representing a pressure of about 190 lb. to the square inch); the pieces were overdone, but not so much as to prevent their being used, for though rather hard they were not porous or discoloured. If in that case there had been a metallic plug in the vulcanizer alloyed to blow off at 340°, he would have been put to very great inconvenience. They were, he thought, apt to magnify the danger of explosions from vulcanizers. He was aware such accidents had taken place, but there was not the same risk, as with steam boilers, in which explosions often took place at the moment the engine was started; any disturbance of the pressure in the boiler appearing to produce a rapid generation of steam, so that an explosion followed if the boiler was faulty. In vulcanizers there was no change in the pressure of the steam, and consequently they were not liable to that risk. Then, again, they were not liable to the risk from excessive heating of the metal. Vulcanizers never had a chance of getting red hot, and it could easily be proved that many steam boiler explosions took place from the iron becoming heated to a red heat, when amongst other evils the steam in contact with it would be decomposed into its component parts, oxygen and hydrogen; the oxygen would combine rapidly with the iron, and so weaken it and render it more liable to explosion. One source of danger arose from the weight falling off the safety valve lever. Such an accident had twice occurred to himself, the safety valve flying out near his head. That was very easily remedied by having the lever kept down by a spring instead of a weight, which plan he had recently adopted.

The Secretary read the following letter from Mr. H. ROTTENSTEIN, of Paris:—

"I take the liberty of calling the attention of the Odontological Society to a new instrument called the Stomatoscope, invented by Dr. Julius Bruck, dentist at Breslau. The Stomatoscope will render great services to diagnose cases, and it will be certain to find its application when the eyes and sunlight are insufficient to find the seat and character of the disease. On first consideration, the practical value of this instrument may be doubted; but this frequently happens with new things.

"Professor Helmholz invented the ophthalmoscope, for a physiological purpose, to examine the interior and background of the eye; and no one thought that one day the ophthalmoscope would be the principal means of detecting pathological conditions and revolutionise the practice of

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ophthalmology. The laryngoscope originated in the same way. Czermak, the inventor of this instrument, used it only for physiological investigations; and its real use, viz., its application to pathological conditions, developed itself afterwards, and gave rise to a new speciality. I could cite other examples, as the endoscope, the stethoscope, etc.; but my object is only to call your attention to this instrument, and to induce some of the members of your society to apply it in our speciality.

"The Stomatoscope is connected with a battery, constructed after the plan of Professor Middeldorpf. This battery combines the advantages of Grove's and Bunsen's, and is certainly superior to any constructed for dental purposes. The two elements may be used together or separately. If a red heat is required, as for operations on the gums or sensitive tooth-bone on the neck of the teeth, etc., one element only is used. When the nerve in a broken tooth is to be destroyed, and white heat required, the two elements have to be put into operation. The galvanic heat may also be used in minor operations, as for instance in drying out cavities before filling.

"Mr. Jenkins, partner of the celebrated instrument-maker, Mr. Lüer of Paris, will be most happy to give all the explanations required; and will put the instrument in operation before the society, as he has seen it applied in several Paris hospitals, at the surgical societies of Paris, by Dr. Bruck and myself.

"The original instrument of Dr. Bruck had some inconveniences, particularly the burning of the wooden tube, and the too great heat evolved by the combined efforts of Mr. Lüer, Mr. Jenkins, and myself, these disadvantages have been overcome."

Mr. Jenkins, of the firm of Lüer, of Paris, exhibited a galvanic reflector. He said it was a simple modification of one used by Professor Middeldorpf, of Breslau, who some years ago brought out an instrument whereby to remove large tumours or a breast. This smaller instrument, with two batteries instead of four, was merely brought out by Dr. Bruck for showing cavities in the mouth, where the lamplight or the sunlight was not sufficiently strong. M. Lüer had made a new improvement, by which the light could be applied either to the larynx or to the teeth. They also had apparatus for burning out the nerve and removing small tumours; it could also be used with four elements to remove a breast. Professor Middeldorpf, some three or four years ago, with the large apparatus, removed a leg in the Anatomical School in Paris. The modification of his apparatus, now produced, was merely for Dentists.

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The SECRETARY read the following Paper by Mr. SIDNEY LONGHURST,

On Lateral Abnormalities.

Some time ago I noted down* what I believed to be a singular liability of the upper laterals, when diseased, to produce palatine abscess, a peculiarity which subsequent observation has tended in a remarkable way to confirm. Not only has this idea been supported, but I am further impressed that there are other peculiarities to which these teeth, both when in a healthy as well as when in a diseased state, are more prone to than others.

That there are certain teeth more subject to disease than the rest is an idea the antiquity of which may be traced back to a very remote period. But from the vague manner in which the several classes of teeth are spoken of by the old writers, as well as the erroneous notions entertained by them as to even their number, render it often difficult to ascertain those really alluded to. Upwards of two thousand years ago, we find Hippocrates writing of the upper teeth—"The third (counting from the front) is more subject to suppuration than all the rest; and the thick flux from the nostrils, as well as the pains of the temples, come chiefly from that tooth." And, again,

* "British Journal of Dental Science," vol. 7.

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the "fifth," or "four-rooted" tooth (by which he must undoubtedly mean the first molar, or sixth), he speaks of as being especially liable to caries—a fact which we know to be well established, and one, by the way, which would seem to show that, centuries before the Christian era, teeth decayed very much in the same fashion as they do now.*

Passing over the peculiarity previously referred to, of the tendency of the upper laterals when variously affected morbidly to produce palatine abscess, I would briefly advert to a few abnormalities connected with them when presenting, *per se*, an apparently healthy condition. The first is that on which I have the least evidence to bring to bear: nevertheless, I think it is such as to merit a passing notice. It is a spontaneous periodontisis, terminating in suppuration, which, on a few occasions, I have found to attack them when their crowns have been perfectly sound; the disease, therefore, being attributable to causes of purely an idiopathic nature. That the periosteum or pulp of a tooth, the osseous structure of which is normal, may occasionally be the seat of spontaneous in-

* Those familiar with the writings of Hippocrates, are aware that the book, "Epidemic," iv. 19, from which this quotation is taken, is one of those which many translators refuse to acknowledge as genuine. Most critics, however, are agreed, that if not actually written by him, it probably emanated from an author contemporaneous, or nearly so. Neither is it altogether clear to me, whether the writer is here alluding merely to a case under description, or to the teeth in general. I opine the latter. But, be this as it may, the extract is curious and interesting.

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flammation and abscess, I think will be admitted, although examples, I am aware, are fortunately very rare. Cases, however, have from time to time been noticed. One of particular severity was recorded by Mr. Belisario, of Sydney, which resulted in the loss of ten teeth (all that remained in the lower jaw) of a young man, and which was supposed to have been caused by a violent cold, which followed a severe wetting when off the Cape.*

The first case I have to note was in the mouth of a young married lady. She possessed a good constitution, with a remarkably fine and perfect set of teeth, without loss or blemish till within a few days of my seeing her. The fault then was the right upper lateral, which had gradually become loose, with its gums swollen and painful. At first I imagined it was caused by some foreign substance, such as a bristle of a tooth-brush, having been inadvertently pushed between or beneath the festooned edge of the gum. I examined carefully, but found nothing; nor could I ascertain that the tooth had sustained any concussion. It bled freely, which I thought might afford relief, so merely recommended an antiphlogistic wash and treatment. The swelling of the gum, however, continued to increase, till an abscess formed, which, discharging, gave at once relief. The tooth

* "American Journal of Dental Science," vol. 3. New series.

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soon afterwards became again firm, and ceased to give trouble.

The next was that of a little girl between eight and nine years of age. The four upper incisors were fully developed, but the left lateral was loose, and half hidden by the swollen gum, particularly by that immediately behind, where there was a small soft swelling. This the mother thought was caused by the undeveloped canine pressing its way through; and I was requested to extract the supposed temporary lateral, to give it egress; which of course I objected to. Examination proved it to be simply an abscess charged with pus; no indication, after probing, of any growing tooth being apparent.

A very singular circumstance connected with the upper laterals is the comparative frequency of their *absence altogether* in some mouths. Doubtless, many practitioners have noticed this omission in two or more mouths of the same family. If we except the wisdom-teeth, I think we may venture the assertion that there is no pair or class the absence of which we have oftener to note; putting, of course, out of consideration those cases where, in childhood, they may have been removed, in error or otherwise, for the purpose of regulation.

A very interesting case of the non-presentation (?) of these teeth I saw only a few weeks since. It was in the *temporary* set of a little girl. Their

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absence had been remarked by the parents; and the child was brought from some apprehension as to the probable influence it might have on the regularity of the permanent teeth. The jaw was well arched, and divisions existed between the centrals and canines, as well as between the centrals themselves; but the alveoli of the former spaces were so thin, as to make it appear as if the missing teeth had been extracted. From this circumstance, as well as from the inference to be drawn from the generally accepted theory of development of Mr. Goodsir—that the sacs of the permanent teeth are thrown off from the follicles of the temporary—I am disposed to think the permanent laterals will *not* be forthcoming. Mr. Tomes, in one of his works, speaks of having in his collection two specimens showing the absence of the laterals in temporary dentures.

A gentleman, a near relative, who has no permanent upper laterals, has recently married a lady in whom, oddly enough, the same teeth are also missing. From both I learn that the teeth were extracted early in life, by country surgeons, to give room for other teeth. Such information, however, must always be received with care, it being rare that children, or even the parents themselves, are able to form a trustworthy judgment on such matters; most having the impression that a tooth with an unabsorbed root must, of necessity, belong to the permanent set. I am curious to see

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if this coincidence will in any way affect the dentures of their children.

A lady whose mouth I was preparing for an upper artificial case, by the extraction of the few remaining loose front teeth, thinking it might influence my judgment in the arrangement of the new set, pointed out the absence of the laterals, and further volunteered the statement that neither had she ever had any in her temporary set: she was quite sure of it, recollecting that it had been the subject of remark by her parents.

Again, the mother of a child of about five years of age called my attention to the absence of the right lateral in the *lower* jaw. The left was in its place, and the whole of the remaining temporary teeth were regularly and well developed; but a space existed where the missing tooth should have been, nor was there the slightest indication of its approach.

It would seem, too, a rather remarkable fact that, in the rare cases of osseous union of teeth, the laterals play a very conspicuous part. Mr. Tomes, on this subject, writes: "The central and *lateral* incisors, or the *lateral* and canines, appear to be the *only* teeth of the temporary set subject to gemination" (the italics are my own). Two cases only of this abnormality have come under my observation, and in both the union was between the central and *lateral;* tending, therefore, in part to corroborate the above.

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In the union of the *permanent* teeth, the laterals also will be found to figure conspicuously. Indeed, in almost all the cases sketched by the several dental writers, in the majority, at least, this tooth will be found involved. A physiological view of the matter would lead us to expect the more frequent fusion of the two centrals; although Disirabode gives the greater probability to the canines with the laterals. But, be this as it may, in the few cases in which Nature by this freak occasionally diverts herself, the *lateral, with* one or the other of its neighbours, seems to bear off the palm of selection.

Again, the mould or fashion of these teeth seems to wander more frequently from the normal *shape* than others. The flattened lower labial surface, so beautifully described in what we are wont to regard as the typical form of lateral, and which, with the non-diastema and short canine, appear to give that expression to the mouth so eminently *human*, oftentimes, in whole families, seems to degenerate into a small misshapen cone or a mere enamelled peg—teeth which, if removed from the mouth, it might well be a subject of conjecture as to what part they had belonged, or whether they had formed any part of the human economy at all!

Several authors have mentioned cases where *three* well-developed laterals have been present. I frequently see a gentleman in whose upper jaw

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there are *three*, all well arranged within the arch, and each perfectly formed. These may perhaps be regarded as merely cases of supernumerary teeth, and such undoubtedly they are. But it is to this that I would point:—The surplus teeth have been *laterals*. And, further, that, in three-fourths of the cases of supernumerary teeth I have seen or heard of, I have noticed that the intruder has generally presented itself in this locality, namely, before, between, or behind the *centrals* and *canines*. And, lastly, that supernumerary teeth, although occasionally simulating bicuspids and dwarfed molars, yet, as a rule, more closely resemble, in size, position, and figure, one of those "misshapen cones," or, in other words, mal-formed laterals, than any other class of teeth.

I add, by way of an appendix, a case which lately came under my notice, and which, from its bearing on this paper and its several interesting particulars, render it somewhat unique.

A lady, æt. about 30, called to have the four lower bicuspids supplied artificially. The spaces on either side were as usually formed, save the extremely sharp and knife-like edge of the alveolar ridges. She told me she had never had teeth in these spaces; and, moreover, that her mother had never had any teeth at all—in fact, that she had been edentulous throughout life. The father's teeth seem to have been regular. The condition of the daughter's mouth was this:—In the lower

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jaw all the teeth were *in situ* and well developed, excepting the four bicuspids, upon the spaces of which the adjacent teeth showed no disposition to encroach. The upper jaw was well arched, with considerable divisions between most of the teeth. Their order was as follows:—

Two centrals—Perfect.
Laterals—Missing.
Canines—Small and peg-shaped.
First bicuspids—Missing; but in their places stood the persistent temporary canines.
Second bicuspids—*In situ*, but remarkably small.
All the molars were regular and well formed.

Without having witnessed the shedding of the first teeth, it is, of course, impossible to say whether the dwarfed canines were *really* canines, or more of the mal-formed laterals. But, be this as it may, in either case we find the laterals prominently implicated.

I know of one other case, a maiden lady, who is reputed to have had no teeth from her birth; but she is otherwise much disfigured and afflicted. Setting aside, however, the latter calamity, the matrimonial chances of such edentated persons are very small: a child, therefore, of such a parent must be considered a *rara avis*, and accordingly worthy of record.

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GENERAL MONTHLY MEETING.

Monday, May 7, 1866.

W. A. N. CATTLIN, Esq., President, in the Chair.

The following Gentlemen were proposed for the Membership of the Society:—

Mr. John Saxty Goode, L.D.S.
Mr. Horatio M. Jones.

Mr. Sercombe presented to the Society a fossil molar tooth of Hyena, from the celebrated Bruxham Collection.

Mr. C. J. Fox brought before the notice of the Society the case of a young woman who, at the age of 27, still retained both her upper and lower laterals and canines, as well as her first upper and lower right temporary molars—in all, six temporary teeth; they were quite firm, with the exception of one of the laterals, which was slightly loose. He had frequently met with isolated cases of temporary teeth remaining at a late period of life. Amongst others, a temporary canine in the mouth of a gentleman of 45, and a temporary molar in another of 42.

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Mr. Ibbetson read a paper—

Upon Fossil Teeth of Fishes in the Palæozoic and Lower Members of the Mesozoic Rocks.

Mr. President and Gentlemen,—As has been observed by Pictet, no class in the animal kingdom can surpass that of Fishes in the interest which it offers to the paleontologist. It is the only class of the Vertebrata which has existed from the earliest geological epochs, and, consequently, whose remains are to be found in *all* the stratified rocks.

Of the eight thousand or more known species of Fishes, about seven thousand belong to the Ctenoid and Cycloid orders, including the majority of Fishes in our present seas, and no instance of the existence of which is known below the Oolitic series; the remaining thousand species belong to the Placoid and Ganoid orders, so abundant in the earlier periods of the earth's history, but now represented by comparatively few forms. Of these it is proposed in the present paper to notice the leading species, genera, and families—known by teeth—as they occur in the successive geological formations, from the Silurian beds up to, and inclusive of, the Lias.

It will be clear that such a paper must be considered a *résumé* of the labours of those who

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have investigated the subject of it; and in order to avoid the charge of unacknowledged plagiarisms, a list is subjoined of the principal authors consulted, from many of whose works copious extracts are made. This avowal will render the frequent repetition of these names unnecessary. Agassiz, Owen, Pictet, Retzius, Cuvier, Hermann von Meyer, Conybeare, Mantell, Sir Roderick Murchison, M'Coy, Buckland, Huxley, Sir H. de la Beche, Hugh Miller, Sir Philip Egerton, Sir Charles Lyell, Bronn, and Morris.

The Fishes of which we are about to treat are referred to two orders—the Placoid and Ganoid; and the earliest evidence we yet have of their existence—as known by teeth—is found in the bone bed of the Ludlow group of the Upper Silurian deposits.

This evidence consists of small portions of jaws having teeth of different forms, but whose affinities have not been clearly determined. Agassiz refers them, with a doubt, to his Placoid order, and to the genera Plectrodus and Sclerodus. Murchison, however, in the last edition of his "Siluria"—on the authority of Sir P. Egerton—supposes them to belong to a small species of Ganoid fish; and Mr. J. W. Salter suggests that these fragments may have belonged to Pteraspis or Cephalaspis, the teeth of these genera being yet unknown.

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From this it will be seen that the evidence alluded to is somewhat equivocal. The first *positive* dental evidence of the existence of the Class is furnished by the teeth of several genera of Fishes in the succeeding formation—the Devonian—in which rocks occur—Ctenoptychius (Plate I., fig. 8) and Ctenodus (Plate I., fig. 10), genera of the Order Plagiostomi, and belonging to the family of Cestracionts. They make their first appearance in these rocks, but obtained their greatest development, both as regards size and number of species, in the Carboniferous period. Their remains, however, range throughout the whole series of stratified rocks up to the present time, and evidence of their existence is to be found in each successive formation.

The Cestracion Philippi, or Port Jackson shark of the Australian seas (Plate III., fig. 17), may be looked upon as the sole existing representative of this family of Fishes, so rich in genera and species in the Paleozoic and Mesozoic ages.

ORDER PLACOIDEI: Agass.

Family—*Cestraciontidæ.*

In zoological classification we commence with the Order Placoidei, and the family of Cestracionts will of course be the first to demand our attention. They are unrepresented in the Silurian,

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and but meagerly in the Devonian rocks, but numerous genera and species are found in the Mountain Limestone of the Carboniferous epoch; of the genus Psammodus, of this family, Agassiz reports three and M'Coy one species.

Psammodus (Plate I., fig. 1) had large, flat teeth, with a uniform sand-like surface, presenting neither ridges, elevations, or nipples. Agassiz attributed the sanded or punctuate character of the surface to the tubular structure of the crown. Professor Owen denies the possibility of this, and states that the "tubes always terminate at a short distance from the surface of the tooth, either by anastomosis, or by subdivision into other tubes of such extreme minuteness, that the combined diameters of five hundred of them would barely equal the breadth of a single superficial punctuation." The same author states that the punctuations "are consequences of the conformation of the original matrix, and are adaptations conformable with the habits and food of the species."

The teeth of Chomatodus (Plate I., fig. 2) resemble those of Psammodus, but are more lengthened out, and surrounded at their base by a series of concentric folds or plications more or less prominent, and more or less numerous. These teeth are sometimes flat, and sometimes more or less convex, or raised in the centre into a sharp edge or ridge. Three species of Agassiz and two of

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M'Coy are found in these rocks; and Hermann von Meyer and Pleininger report one species in the Muschelkalk division of the Trias.

Helodus (Plate I., fig. 3) had teeth, the surface of which was perfectly smooth, the centre being developed in the form of an obtuse cone. Sometimes they present a series of these cones, at other times only one; nine species of Agassiz and two of M'Coy are found in the Mountain Limestone.

The teeth in Cochliodus (Plate I., fig. 4) are less numerous than in the preceding genera, but each individual tooth is rolled or coiled up, as it were, upon itself, and covers a larger surface of the maxilla; indeed, a single tooth occupies the space covered by an entire row in the Cestracion Philippi. These fishes are peculiar to the Carboniferous period, in which Agassiz enumerates five species.*

Pœcilodus (Plate I., fig. 5) is very little known. The teeth are slightly convex, hollowed out below, polygonal, or rounded in form, and marked on their sides with parallel plications or folds. Agassiz enumerates six, M'Coy two, and Keyserling one species, in the Carboniferous Limestone.

* Since this paper was read, Professor Owen, in an article in the "Geological Magazine" for February, 1867, separates Cochliodus from the Cestracionts, and of its species makes four genera—viz., Cochliodus, Tomodus, Streblodus, and Xystrodus, — which he forms into a new family—Cochliodontidæ.

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Orodus (Plate I., fig. 6) was furnished with long teeth of a porous structure, and bevilled off at their sides to a sharp edge. The middle portion of the tooth is raised so as to form an obtuse ridge; oblique lines pass from the longitudinal ridge, which may not unaptly be compared to a mountain-chain with a corresponding series of valleys. Agassiz and M'Coy each furnish two species of the genus in the rocks before us.

Petalodus (Plate I., fig. 7) forms a very special type, and one which may possibly not belong to the Cestracionts at all. The difficulty of finding its true generic affinities has prompted Agassiz, however, to class it *provisionally* with the family. The teeth have concentric plications around the base, which is broad and finely punctated. The middle portion of the tooth is raised vertically into a ridge, with a well-defined trenchant edge. The termination of the enamel on both sides is convex towards the base of the tooth, contrary to the terminal contour of the enamel in the compressed teeth of the sharks. All the species belong to the Carboniferous epoch. Agassiz enumerates six, and Owen and M'Coy each one species.

Ctenoptychius (Plate I., fig. 8). This genus has already been alluded to as furnishing with Ctenodus (Plate I., fig. 10), and other genera, the first positive evidence by teeth of vertebrate life, and feebly represented, in the Devonian rocks,

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by two species only of Agassiz. They attain, however, their plenary development in the formation now under our consideration, where Agassiz enumerates seven species. The teeth of Ctenoptychius resemble those of Orodus, but they are small, very much compressed, and the transverse ridges are so arranged as to form a kind of comb, the teeth of which are more or less detached.

Campodus (Plate I., fig. 9), on the authority of De Koninck, has been found in the Carboniferous rocks of Belgium. The teeth are very complicated; they are oblong, with the borders parallel to each other, the crown surmounted with numerous detached oblong tubercles placed across the tooth.

Ctenodus (Plate I., fig. 10) has been already referred to in association with Ctenoptychius (Plate I., fig. 8) as having been found in the Devonian deposits of Russia, on the authority of Eichwald, in which Agassiz cites two species — Keyserlingii and Woerthii — to which M. Eichwald adds two more—serratus and radiatus. I am precise in naming the species of this genus found in the Old Red Sandstone, because, in conjunction with Ctenoptychius, it constitutes one of the earliest known *positive* instances of the existence of Vertebrata *evidenced by teeth.* Ctenodus is at present only known by a small number of teeth in the form of a fan, the sides of which were

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notched; on such meagre data their description must obviously be imperfect. It should be stated that Hugh Miller and others consider the teeth of the Devonian Ctenodus to be those of the genus Dipterus of the Ganoid Order—to be referred to hereafter.

The teeth of Pleurodus are noticed by Agassiz as having been found in the Bituminous shales of Carluke, but no description of them has been yet given.

The next series of rocks in the order of stratigraphical superposition is the Permian, and which bounds or terminates the Palæozoic period. No instance exists of teeth of any genera of the Cestracionts having been yet found in these rocks. We pass on, therefore, to the Trias situated at the base of the Mesozoic or Secondary period, where we find the family fairly represented.

Three species of Strophodus (Plate I., fig. 11) are found in the Muschelkalk—a formation absent in England—forming the second member of the Triassic series, and immediately overlying the Bunter sandstone, being the lowest of the Triassic deposits; and the Keuper immediately overlying the Muschelkalk furnishes one species. The teeth of the genus are somewhat elongated, more or less contracted, truncated at the extremities, and sensibly twisted throughout their long diameter. The surface is reticulated in some, and punctated in others.

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Agassiz enumerates three species of Acrodus in the Muschelkalk members of the Trias, and Von Meyer one. Two species of the genus, according to Agassiz, are found in the Rhætic beds. The presence of these species of Acrodus in these beds is merely alluded to. The description will be deferred until we come to notice the Liassic species.

Hermann von Meyer and Pleininger describe four species of Thectodus in the Keuper beds, or upper division of the Trias. The teeth of the genus are described as having no transverse plications, the median ridge as having a very sharp edge, and the centre of the tooth raised in the same way as was described in Orodus.

Teeth of Ceratodus (Plate I., figs. 12 and 12*a*) are found in the Muschelkalk, Keuper, and Rhætic beds; Agassiz has established ten species. In *structure* the teeth of Ceratodus resemble those of Psammodus, already described, but *the anatomical characters* are very different. One of their sides is always quite plane, while the other side has angular, conical, and undulating projections or digitations. Pictet suggests the improbability of there having been many rows of these teeth. The straight side was probably the internal one, and *that* with the projections or digitations the external. The smallest side was certainly the most anterior, from which it follows that the processes have their points directed outwards or in front, and that the pos-

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terior ones were the largest. The forms of the teeth of Ceratodus must have been very various, for Mr. E. T. Higgins, in a note published in Morris's catalogue, thus expresses himself:—"I can now show about 140 forms or varieties of forms, and with each addition to my series I am more and more puzzled with them, as I scarcely ever meet with a duplicate. The species must have been very numerous, or else the teeth in different parts of the mouth must have varied as much as in some of the sharks, for I cannot fancy that each individual had only four teeth, as in the Chimæroids." These teeth are composed of two very different tissues. The superficial one consists of an enamel having tubes very closely packed together. The deeper seated tissue is osseous.

The last and most interesting genus of the Cestracionts to be noticed is Acrodus (Plate II., fig. 16); species have been already referred to as existing in the lower beds we have noticed. The genus has a considerable geological range, extending as high up as the Cretaceous formations. The greatest number of species is found in the Lias, where, however, no other Cestracion has been yet observed. Agassiz has established five, and Giebel one species in this formation. No other genera of the family present so close an affinity with the existing Cestracion as that before us. The fossils on the table are the

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species *nobilis* and *latus* found in the Lias, and on comparing them with the Port Jackson shark of the Australian seas (Plate III., fig. 17)—a preparation of which is also on the table—whether the character of the individual teeth, the obliquity of their linear arrangement, or the number of teeth in each row be taken into consideration, the affinity—it might almost be said identity—must be at once apparent. The genus assumes, therefore, an extraordinary interest from the faithful interpretation which is afforded of its nature by its consanguinity with the Cestracion Philippi. In anatomical character, the length of the crown is equal to about three diameters of the centre, which is the broadest part. The teeth, however, become narrower towards the extremities, which are rounded off, though not symmetrically. They are convex both laterally and longitudinally. The surface is marked by a ridge, which traverses the centre of the tooth from end to end, and from which transverse striæ diverge with more or less uniformity. The base of the tooth is somewhat narrower than the crown. In structure the teeth of Acrodus present features of great beauty and interest, and, as Professor Owen observes, afford the most instructive illustration of the relation of dentine to bone; but it is not within the province of this paper to notice these characters. This will complete our list of the Cestraciont family.

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FAMILY—*Hybodontidæ.*

The next family of the Placoid or Plagiostomous fishes to come under our notice are the Hybodontidæ, which make their first appearance in the Devonian rocks, in the genus Cladodus (Plate I., fig. 13). One species only, the *simplex* of Agassiz, has been found in this system, in the neighbourhood of St. Petersburg. They are more numerous in the Carboniferous formation, where Agassiz enumerates eight species, and M'Coy and Portlock each one more. The genus dies out in the last-named rocks. The characters of the teeth are well defined, consisting of a large central cone, and smaller lateral ones, gradually increasing in size to the end of the tooth.

The genus Diplodus (Plate I., fig. 15) makes its first and last appearance in the Coal measures, where Agassiz describes two species. The principal character of the teeth consists in the excessive development of the lateral cones, the apices of which diverge from the mesial line of the tooth by a graceful curve; the mid-cone in this genus is, comparatively speaking, rudimentary, a feature the very opposite, both of the preceding, and of the type genus Hybodus (Plate I., figs. 14 and 14*a*), which is represented in the Muschelkalk and Keuper divisions of the Trias, in the Rhætic beds, and in the Lias, and ranges throughout the Oolitic and

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Cretaceous deposits. Agassiz describes four species in the Muschelkalk, founded upon the teeth, to which Hermann von Meyer adds a fifth. Agassiz refers three species to the Keuper, also founded on the teeth, and Von Meyer and Pleininger place four species in the same formation. Three species of Agassiz and one of Giebel are found in the Lias. In this genus the cones are more or less flattened; the central, as in Cladodus, being the largest, and the lateral ones gradually diminishing in size towards the margin of the tooth.

Thus it will be seen that while these three genera of the family have some dental characters in common—the crowns of the teeth being made up of a series of cones—yet each genus has also its *special* feature. In Cladodus and Hybodus we have the central cone the largest, but in the former the secondary cones increase in size towards the end of the tooth, while in the latter they diminish in size in the same direction. In Diplodus we have these characters reversed, in the comparatively rudimentary central cone, and the largely developed lateral cones.

The whole family of the Hybodonts have the teeth marked with longitudinal striæ, or plications, which, however, vary in their arrangement in the different species. The base of the teeth is osseous, the crown is coated with enamel.

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ORDER GANOIDEI: AGASS.

FAMILY—*Cephalaspidæ.*

The Order next in succession to be noticed is the Ganoidei, commencing with the family Cephalaspidæ.

It was mentioned in the early part of the paper that no teeth of Pteraspis or Cephalaspis have been yet found. But should the accuracy of Mr. J. W. Salter's suggestion be confirmed, that the portions of jaws having anchylosed teeth, already referred to, belong to Pteraspis or Cephalaspis; this would, according to the plan of the present paper, be the proper place to notice them, as the earliest instances of the order now under consideration, known by their teeth. These genera would indeed then gain additional interest, inasmuch as they would become the earliest known indication of the existence of fishes; for the remains of Pteraspis and Cephalaspis have been found below the Ludlow Bone-bed of the Upper Silurian rocks, in which formation Agassiz places Plectrodus and Sclerodus.

Agassiz enumerates ten species of the genus Pterichthys in the Old Red Sandstone. Sir P. Egerton and Hugh Miller furnish one species in the same formation, quadratus; and Pander furnishes the cellulosus. Little is known of the teeth of this genus except that it had small

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conical bony teeth in either jaw united at their bases.

The same rocks furnish four species of Coccosteus of Agassiz. Pander adds one, obtusus; M'Coy, three. The latter authority adds, though as doubtful, one species in the Carboniferous formations. Both upper and lower jaw of Coccosteus were furnished with from ten to twelve pointed equal teeth on each side; but, as Hugh Miller remarks, these organs, instead of being placed *on* the bone, like those of fish of the common varieties, are confluent with the bone of the base, and equally destitute of ganoine, or the shiny enamel tissue which invests both the scales and bones of the exo-skeleton as the enamel invests the teeth of other genera. M'Coy states that the teeth have the middle occupied by a coarse network of irregular, tortuous, medullary canals from which the fine calcigerous tubes radiate. It may be remarked that the doubtful affinities of Coccosteus have given rise to the question of classifying the genus with fishes or crustacea.

The next family to be noticed are the Cœlacanthi. The teeth of the family are conical, and longitudinally plaited at the base. They are of two sizes: the smaller very numerous; the larger few, far apart, and set rather within the line of the smaller ones.

Large incisor teeth of two species, of the genus Bothriolepis, have been found in the Devonian

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rocks—favosa of Agassiz, and ornata of Eichwald. They are plicated at their base, and very much resemble those of Holoptychius.

Several species of Glyptolepis, having numerous sharp, conical, fluted teeth implanted in imbricating plaited sockets, have been found in the same beds.

The allied genus Holoptychius, also of this period, presents the same dental characters. This genus has been the subject of some controversy, inasmuch as the species found in these rocks have been referred by some writers to the preceding genus, while those in the Carboniferous rocks, which were chiefly founded upon the teeth, have been referred by Owen and others to Rhizodus.

Five species of Dendrodus (Plate V., fig. 18) are found in the Devonian series; three of Owen, and two of Agassiz. The genus is only known by the teeth, which have been referred by Eichwald and others to Asterolepis. These organs are cylindriconical in form, with a round obtuse summit, more or less curved, and the surface marked by fine longitudinal striæ, very clear towards the base, but becoming less distinct and ultimately obliterated towards its apex.

From the somewhat analogous structure of the tooth of Dendrodus with that of the extinct Amphibian, Labyrinthodon, Professor Owen has some hesitation in classifying the genus with

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fishes; and, from these structural characters of the teeth, he suggests the probability of the animal having approached in its general organization the confines of the Reptilian class, and having therefore possibly linked some extinct group of fishes with the Labyrinthodonts.

The genus Dendrodus, as conditionally established by Owen, has been subdivided by Agassiz into Dendrodus (Plate V., fig. 18), Lamnodus (Plate V., fig. 19), and Cricodus (Plate V., fig. 20). The genera Lamnodus and Cricodus are, like Dendrodus, also known by the teeth only, and species of each genus are found in the same deposits as the preceding. The teeth bear a general resemblance to those of Dendrodus, but in Lamnodus are more compressed, slender, and the apices more pointed; the root only is round; while in Cricodus these organs are robust and blunt-pointed.

The genus Rhizodus (Plate IV., fig. 21) is characterized by a row of numerous thickly-set, sharp, conical teeth, running along the edge of the mouth. Inside this row was a second and widely-set row of at least twenty times the bulk of those composing the outer row, and which—to use the language of Hugh Miller—stood up over and beyond them like spires in a city over the rows of lower buildings in front. These enormous laniary teeth were from three to five in number on each side in both jaws, and in their proportions, as Professor

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Owen observes, they compete in size and strength with those of the largest Ichthyosaurs and Crocodiles. They have an elliptical section with sharp cutting edges, and were therefore calculated to perform the double function of piercing and cutting. The base is irregularly fluted in the longitudinal direction, and sinks deep into the substance of the jaw. The presence of these large teeth, the elliptical section, and greater number of small conical teeth which occupy the interspaces between the large ones, constitute the dental distinction between Rhizodus and Holoptychius; the section of the teeth in the latter being circular instead of elliptical.

The fragment of a jaw of Rhizodus, in the possession of the Royal Society of Edinburgh, is 18½ inches in length, and it is furnished with teeth, one of which from base to point measures 5 inches and another 4½. The Rhizodus of the Coal measures has been pronounced by Agassiz the largest of all osseous fishes.

The Cœlacanthus is the type of the family. The teeth are analogous to those of the Lepidostei; the genus is represented by species in the Carboniferous, Permian, and Triassic beds.

The next family of the Ganoid Order to come before us are the Dipteridæ, the typical genus of which—Dipterus—was the first, or nearly the first, of the Devonian fishes to be described by Murchison and Sedgwick. On the authority of

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Hugh Miller, the teeth are exclusively palatal—and, to use his own words, "blunt, squat, and arranged in two rectangular patches," and identical with those of Ctenodus, which he thus associates with the present genus.

The figure 22*a*, Plate V., shows the base of the cranium of Dipterus with the angular patches of palatal teeth alluded to. The singular form of the inferior maxilla of Dipterus (Plate V., fig. 22) may be noticed. Hugh Miller truly remarks that no other fish-jaw—whether of recent or extinct races—might be so readily mistaken for that of a quadruped. It exhibits not only the *condyloid*, but also the *coronoid* processes; and save that it broadens on its upper edges, where in mammals the grinders are placed, so as to furnish field enough for angular patches of teeth, which correspond with the angular patches in the palate, it might be regarded—found detached—as at least a Reptilian if not Mammalian bone.

This author remarks with regard to Osteolepis—a genus of the same family and the same geological period,—"We are accustomed to see vertebrated animals with the bone uncovered in one part *only*—that part the teeth—and with the rest of the skeleton wrapped up in flesh and skin; the enamelled, slender, sharply-pointed, and thickly-set teeth were placed in jaws which presented outside a surface as naked and finely-enamelled as their own."

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The teeth of the contemporary genus Diplopterus present the same affinities as those of the last named, only that they were larger and more isolated than in Osteolepis. The distinguishing character of these two genera being the relative position of the fin rays.

There remain, in the Old Red Sandstone, of this family, the genera Gyroptychius and Triplopterus. The teeth are minute, slender, and conical, of nearly equal size in the former; and rather distant, apparently in several rows, and of irregularly unequal size in the latter.

It ought to be noticed that the members of this family found in the Devonian rocks were but a few years ago increased by the addition of Stagonolepis. The genus has, however, been elevated—so to speak—by Professor Huxley to the rank of a Reptile. It would be irrelevant to examine *all* the data upon which the transference of Stagonolepis from the Class Fishes to that of Reptiles was made. Suffice it here to remark, that the characters, and eminently Crocodilian mode of implantation of the teeth, abundantly testified to the proper position of the genus in the zoological scale.

The genus Megalicthys is represented in the Devonian rocks by one species of Eichwald. The conical laniary teeth are of large size, and resemble those of Saurians, and the Megalicthys has been taken for a Reptile, and cited as a proof of the

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early appearance of this class; but from the strong osseous plates of the head—similar to those of the Polypterus of the Nile—and from the beautifully enamelled and finely-punctated scales of its body, its affinity with the class Fishes is satisfactorily established.

Two species have been found in the Coal measures. This genus, like its contemporary Rhizodus, appears to have had but a short range in geological time. As no species of either have as yet been discovered in any later deposit, we pass on to the next family of the Ganoids, Acanthodei, Agass. The typical genus—Acanthodes—one of the earliest to appear, is found in the Old Red Sandstone. All that is known of the teeth is that the mouth is furnished with numerous small teeth, among which a few large conical ones are irregularly interspersed.

The same rocks furnish several species of Cheirolepis. The mouth of the genus is very large and the teeth small; according to Agassiz, the large and small teeth are in one row, and not the latter, forming a continuous row outside the others, as in the Sauroidei and Cœlacanthi. Several genera have recently been added to this family, but very little is known respecting their teeth. Species of Acanthodes are found in the Coal measures, and in the Permian rocks.

The next family of the Ganoid order are the Sauroidei.

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The teeth of this family are of two kinds in each jaw; a few large, conical, pointed, laniary ones, alternating with very numerous sub-equal minute teeth "*en brosse*," or brush-teeth, of Cuvier.

The genus Pygopterus is represented in the Coal measures by several species. The principal feature of interest in the present paper consists in the fact of the upper jaw being a little longer than the lower, foreshadowing a condition which we shall find more strongly marked in a genus to be hereafter noticed.

The genus Saurichthys is known by the detached teeth only, and several species are found in the Triassic and Rhætic beds (Plate V., fig. 23 *a*, *b*, *c*, and *d*). The teeth have often been mistaken for those of Saurians; they have vertical lines, and are lodged in grooves similar to those of the Plesiosaurus. Their microscopic structure, however, proves them to be the teeth of Sauroid fishes.

Passing up into the Lias, we find Eugnathus represented by eleven species of Agassiz; Pictet remarks that the teeth of the genus are characteristic of voracious fishes; that those of the species orthostomus, of Agassiz, are very large; those of the inferior maxilla in speciosus, much varied; and that the species polyodon, is well characterised by its teeth, which are so arranged that a large and small one alternate with each other.

The Lias also furnishes species of Ptycholepis, Sauropsis, and Pachycormus; Pictet states that

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the robust maxillæ of the last-named genus are armed with conical teeth.

In the same beds (Lias) are found species of Leptolepis, characterized by long and slender teeth "*en brosse*," or brush-teeth; associated with these, however, and situated at the back of the mouth, were other and larger teeth.

Aspidorhynchus (Plate V., fig. 24) and Belonostomus of Agassiz were contemporary with the five last-named genera. The former was distinguished by the extreme shortness of the inferior maxilla, and the enormous prolongation of the superior maxilla beyond it into a sort of beak. These bones were furnished with numerous teeth of unequal size, and which were articulated even on the projecting portion of the upper jaw, and were therefore unopposed by teeth in the opposite jaw. In Belonostomus, the two maxillæ were proportionately longer, more slender, and of equal length, but the teeth were of the same form and character as in Aspidorhynchus.

The next family of the Ganoid order are the Lepidoidei, Agassiz. The teeth of the family are very minute, and in numerous rows *en brosse*—or obtuse and in one row. They make their first appearance in the Coal measures, where several species of Amblypterus and Palæoniscus are found. According to Agassiz, the maxillæ of both genera were furnished with strong teeth *en brosse*, but so minute as to be scarcely visible.

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Elonichthys is distinguished from the two preceding by the maxillæ being covered with granulated longitudinal striæ. These granules have been confused with teeth *en brosse*, and with which are intermingled, large, conical, and pointed teeth. Species are found in the Carboniferous formation.

The genus Eurynotus is limited to the Carboniferous rocks. Sir Philip Egerton has shown that the teeth, although apparently allied with those of the Pycnodonts, have the character of those of the Lepidoids, and the affinity is confirmed by the identity of the scales of Eurynotus with those of this family.

The Permian and Triassic beds furnish several species of Palæoniscus and Amblypterus, the teeth of which have been already referred to.

The genus Dipteronotus is found in the Trias; Sir Philip Egerton describes "the mouth as small and to all appearance edentulous."

Amblypterus, already alluded to in the Coal measures, reappears in the Muschelkalk.

Ascending into the Lias, we find the family represented by several genera. The *type* genus Lepidotus (Plate V., fig. 25) is found in this formation. Agassiz enumerates eight species in the Lias, and Count Münster furnishes two species, one of which—parvulus—is characterized by small hemispherical teeth, surmounted by a button or nodule. Sir P. Egerton adds the species, pecti-

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natus, Quenstedt the dentatus, and Crivelli, Trotti. There are numerous other species, but they are found in more recent rocks, particularly in the Wealden, where, though fewer in species, they attain their greatest size, and finally disappear in the Cretaceous system.

According to Agassiz, the margins of both the maxillary, and intermaxillary bones, are beset with small teeth; the outer row presenting the form of circular, obtuse cones, and within these are many rows of smaller hemispherical teeth, some of which are sessile, whilst others are more or less constricted at their base, and supported on a short pedicle.

Pholidophorus is found in association with the Lepidotus. Agassiz enumerates ten, and Sir Philip Egerton three species. The dental characters of the genus differ from those of Lepidotus, Pholidophorus being furnished with teeth "*en brosse.*" The members of this genus were fishes of comparatively small size, contrasting strongly with those of its allied genus Lepidotus.

The genus Semionotus has a considerable range in geological time. It makes its first appearance in the Lias, where it is represented by five species of Agassiz. The long and narrow maxillæ were armed with fine teeth "*en brosse.*"

The genus Amblyurus is peculiar to the Lias, and one species only—viz., the macrostomus of

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Agassiz, is known. The mouth is armed with small pointed teeth.

The genus Dapedius, established by Sir H. de la Beche, also has no range beyond the Lias; the species, however, are numerous. Agassiz furnishes six species. According to Owen, the teeth, particularly the exterior ones, are stronger and better developed than in Amblyurus. The summit of the crown "is notched, or bifurcate; and this modification is not due to usage or compression, for the teeth of all the rows and in both jaws exhibit the same character, which is also well marked in the successional teeth that have not come into place. In Dapedius Orbis, the teeth of both jaws are strongly dilated and compressed from before backwards, at their summits, and resemble a chisel with a bifid cutting edge." Agassiz assigns pterygoid as well as palatine and intermaxillary teeth to the genus Dapedius.

The generic prefix Æchmodus has been applied to certain fishes, contemporaries of the preceding genus, which were formerly described as species of Tetragonolepis, a genus of the Pycnodont family. They have now, however, been proved to belong to the Lepidoids, and Sir P. Egerton has established the group into the genus Æchmodus, from the character of the teeth.

The notched or bifurcate character of the teeth of Dapedius has been just noticed. Now the principal difference in the teeth of the genus

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under consideration consists in their being *pointed*, these organs being in fact bicuspid in the former—unicuspid in the latter; and on the last-named dental character, Sir P. Egerton has established the genus Æchmodus (*αἰχμή, a point*, and *ὀδούς, a tooth*).

The Legnonotus, whose remains have also been found in these beds, will be the last genus of the Lepidoid family to be noticed in the present paper. According to Sir P. Egerton, the lower jaw is strong, and armed with a single row of stout incurved teeth, in the form of elongated cones, with rather blunt points not unlike the outer row of teeth of some of the more slender toothed Lepidoti or Æchmodi.

The last family of the Ganoid order to demand our attention, and the concluding one of the present paper, is the Pycnodontei.

Pycnodontei.

The teeth are not so uniform in character as those of the family we have just noticed. They somewhat resemble in form the teeth of the Lepidotus. In some of the genera these organs attain considerable proportions—in others they are smaller and arranged in several rows. They may be situated in the intermaxillary, premandibular, palatine, and vomerine bones.

The genus Platysomus makes its first appearance in the Coal measures, where it is represented

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by the species, parvulus, of Agassiz. The same authority furnishes five species in the Magnesian, Limestone, and Permian beds; viz., gibbosus, rhombus, striatus, macrurus, and parvus. Quenstedt is of opinion that the four first-named constitute one species. Count Münster describes three species in these beds—intermedius, Althausii, and Fuldai. The gibbosus is associated with the latter.

The teeth are obtuse and circular in form; they are flattened on the triturating surface, and have a narrow base, "a strong constriction marking the lower boundary of the ganoine."

Sir P. Egerton has recommended the classing this genus with the present family, rather than with the Lepidoids, from the mode of articulation of the scales and from the teeth.

Allusion has been made to the recent removal of Stagonolepis from the class before us, to that of Reptiles, on evidence furnished in great measure by the teeth. Placodus, whose remains have been found in the Muschelkalk, had been referred by Count Münster and Agassiz, to the Pycnodont family of fishes, and would, therefore, have been included in this part of our paper. The basis upon which Professor Owen has classified Placodus with the Reptilia forms the subject of an elaborate paper in the "Philosophical Transactions." It is only necessary here to remark that the data, upon which the amended classification has been established,

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were principally furnished by the dental distinctions, and other correlations of structure which Professor Owen points out.

In the Lias, the genus Tetragonolepis (Plate V., fig. 20), established by Professor Bronn, is represented by several species. The teeth are described as *en masse*, and in many ranges; the summit of the crown being pointed.

We conclude our list with the type genus of the present family—Pycnodus—which attained its greatest development both in size and number of species during the Jurassic period; it has, however, an enormous range in geological time, numerous species being found throughout the subdivisions of the Lower, Middle, and Upper Oolite, the Wealden, and many members of the Cretaceous formation. It extends into the Cainozoic or Tertiary period, species having been found in the Eocene, and, on the authority of Von Meyer, even in the Miocene. Of all its numerous species, one only is found in the beds which form the boundary of the present paper. In the Lias, on the confines of the Inferior Oolite, has been found the Pycnodus Liassicus of Sir P. Egerton. The species is founded on a specimen in the collection at the British Museum, which is believed to be unique, and thus becomes the precursor of the numerous species in the beds alluded to.

The teeth of the genus, which are semi-cylindrical in form and rounded at the ends, have been

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compared by Pictet to a bean. The mouth may be said to have been carpeted, as it were, with these teeth. The maxillæ were furnished with three or four rows, but their exact number and disposition have not yet been ascertained. On the vomer they are arranged in five rows, a central row composed of large bean-shaped teeth placed transversely, and two lateral rows of smaller ones more circular in form and alternately arranged. At the end of the muzzle or snout, both above and below, were two or more large trenchant chisel-shaped teeth.

The dental characters of the numerous species of this genus have been described and figured by Agassiz, Pictet, and others; but ranging in rocks of more recent formation than the Lias, they do not come within the scope of the present paper.

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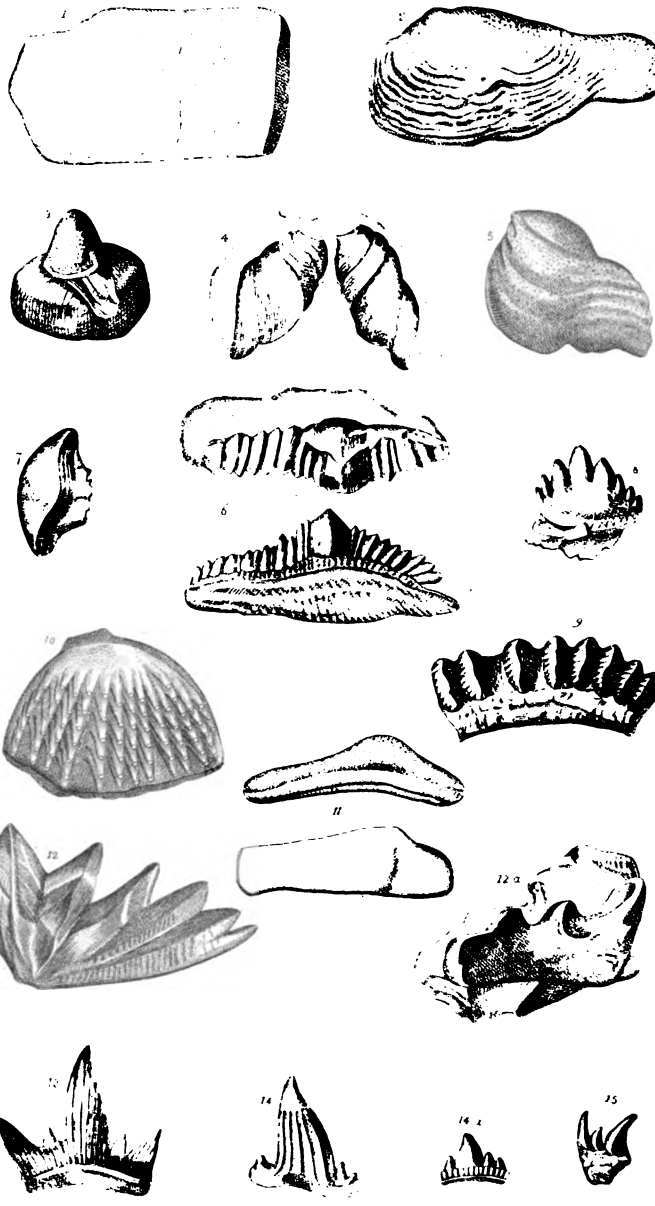
Pl. I



W. Bagg. lc.

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EXPLANATION OF PLATE I.

Fig. 1.—Psammodus porosus. *Agass., from Pictet.*
Fig. 2.—Chomatodus cinctus. *Agass.* ,,
Fig. 3.—Helodus simplex. *Agass.* ,,
Fig. 4.—Cochliodus contortus. *Agass.* ,,
Fig. 5.—Pœcilodus. *Agass., from Nature.*
Fig. 6.—Orodus cinctus. *Agass., from Pictet.*
Fig. 7.—Petalodus. *Owen, from Nature.*
Fig. 8.—Ctenoptychius apicalis. *Agass., from Pictet.*
Fig. 9.—Campodus Agassizianus. *De Koninck,* ,,
Fig. 10.—Ctenodus cristatus. *Agass.* ,,
Fig. 11.—Strophodus tenuis. *Agass.* ,,
Fig. 12.—Ceratodus serratus. *Agass.* ,,
Fig. 12*a*.—Ceratodus altus. *Agass.* ,,
Fig. 13.—Cladodus mirabilis. *Agass.* ,,
Fig. 14.—Hybodus apicalis. *Agass.* ,,
Fig. 14*a*.—Hybodus polyprion. *Agass.* ,,
Fig. 15.—Diplodus gibbosus. *Agass.* ,,

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EXPLANATION OF PLATE II.

Fig. 16.

Fossil teeth, in situ, of Acrodus nobilis.

From Nature.

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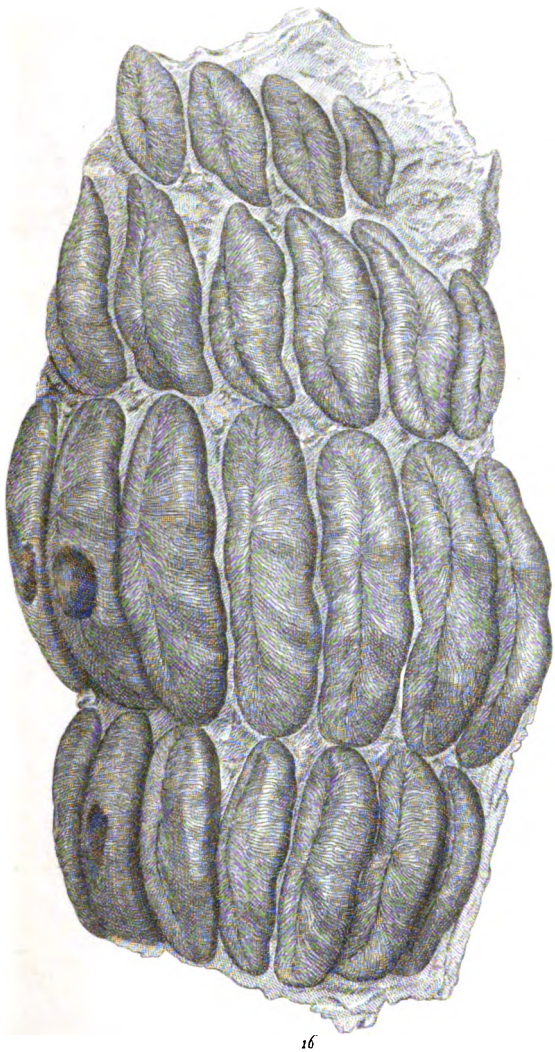

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W. Bagg ad nat. del. et Sc.

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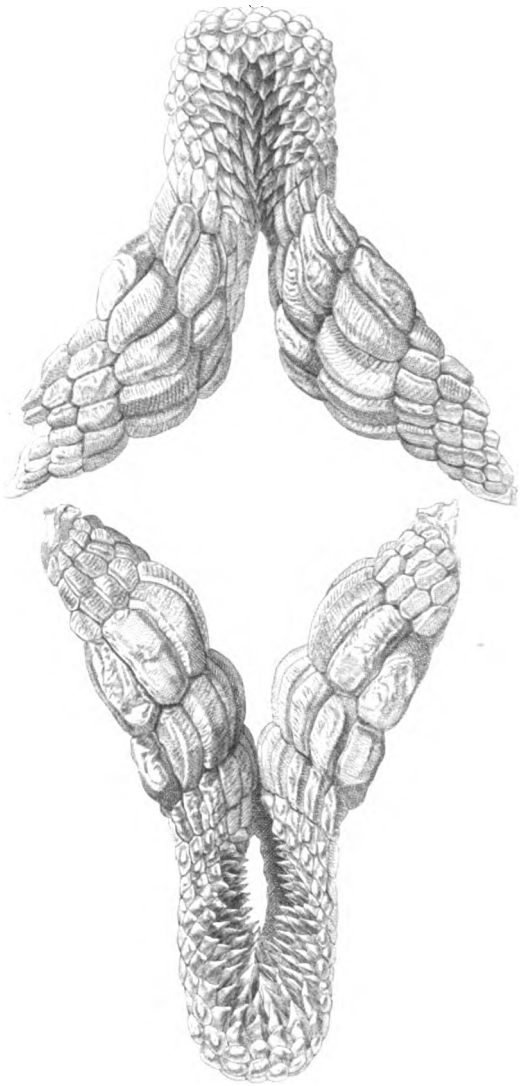

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EXPLANATION OF PLATE III.

Fig. 17.

Upper and lower jaw and teeth of Cestracion Philippi. ***From Nature.***

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EXPLANATION OF PLATE IV.

Fig. 21.

Portion of lower jaw of Rhizodus gracilis. *M'Coy.*

One of the laniary teeth is shown in situ; the letters *a*, *b*, and *c* indicate the localities where the other laniary teeth were apparently situated, but which have been broken off in the specimen.

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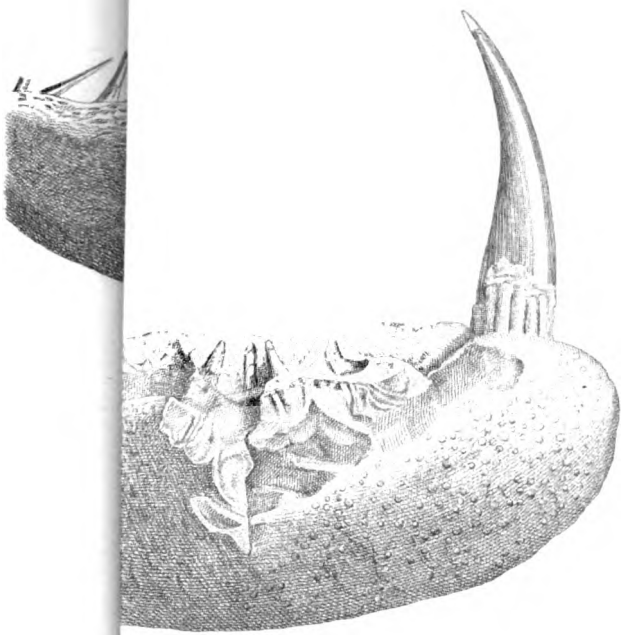
Pl.IV



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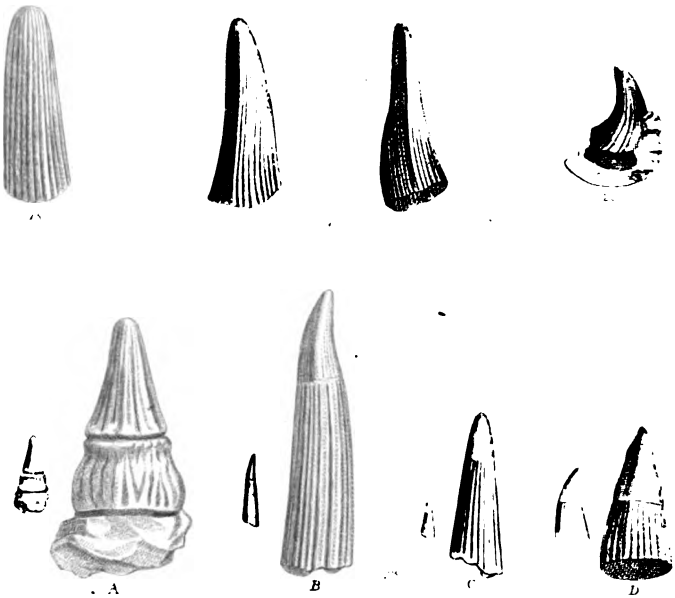

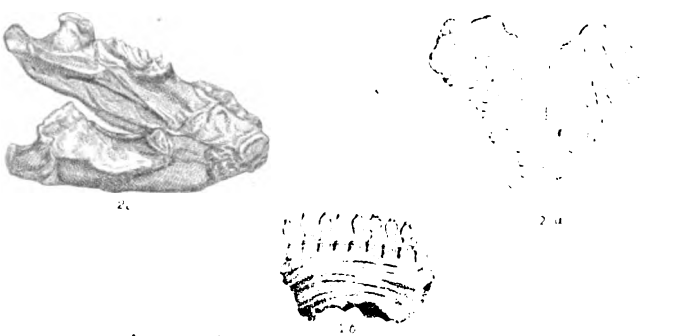

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EXPLANATION OF PLATE V.

Fig. 18.—Dendrodus strigatus. *Owen, from Pictet.*

Fig. 19.—Lamnodus biporcatus. *Owen,* ,,

Fig. 20.—Cricodus incurvus. *Agass.* ,,

Fig. 22.—Lower jaw of Dipterus. *Hugh Miller.*

Fig. 22*a*.—Palatal teeth of Dipterus. *From Nature.*

Fig. 23.—*A*. Saurichthys acuminatus. *Agass.*
B. Saurichthys longidens. *Agass.*
C. Saurichthys apicalis. *Agass.*
D. Saurichthys Mougeoti. *Agass.*
} *from Pictet.*

The small figures are intended to represent the natural size of the teeth.

Fig. 24.—Aspidorhynchus. *Agass., from Pictet.*

Fig. 25.—Lepidotus Mantelli. *Agass.* ,,

Fig. 26.—Tetragonolepis.mastodonteus. *Bronn.*

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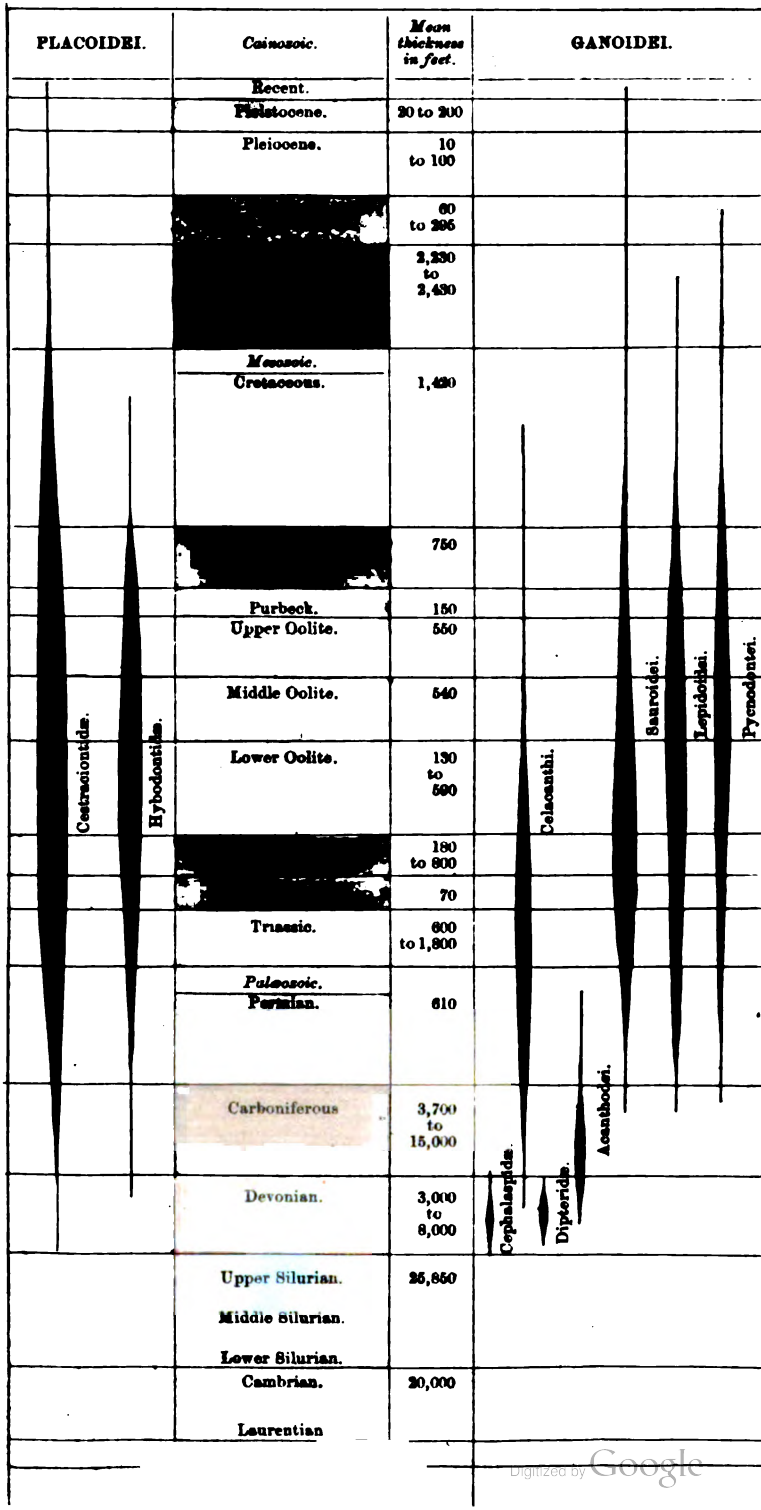
TABLE OF THE GEOLOGICAL DISTRIBUTION OF THE FAMILIES OF THE PLACOID AND GANOID ORDERS OF FISHES,

REFERRED TO IN THE ACCOMPANYING PAPER.



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GENERAL MONTHLY MEETING.

Monday, June 4, 1866.

W. A. N. CATTLIN, Esq., President, in the Chair.

The following Gentlemen were recommended by the Council as Honorary Members of the Society:—

John Flint South, Esq., F.R.C.S.
James Luke, Esq., F.R.C.S.
F. Carpenter Skey, Esq., F.R.C.S.
Samuel Ghrimes, Esq.

The following Donation was made to the Museum of the Society:—
By Mr. Hulme.—Canine tooth of the Musk-deer.

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Mr. BALKWILL read a Paper on—

The best Form and Arrangement of Artificial Teeth for Mastication.

SIR,—Having felt dissatisfied with the masticating efficiency of such dental substitutes as have either been fitted by myself, or otherwise come under my notice, I have for some time been paying attention to the means of making a more successful dental apparatus. The results of my observations and experiments I have ventured to make the subject of the following paper.

The first idea which occurred was to imitate the form of the natural organs as nearly as possible; but this was found more easy in theory than practice; often, from inaccuracy in the bite, the patient complained that his teeth jarred whilst eating, the cusps of the lower piece getting entangled in those of the upper, and they had to be cut off.

Like the contrivance of an ingenious Chinese blacksmith, who wished to purloin a valuable English lock left with him to repair, and substituted for it an imitation of his own, so well done that the fraud was only detected by the owner finding the machine would not lock; so the teeth might look very natural, but they would not bite.

In the first place, it will, perhaps, be best to enumerate those conditions of the natural organs

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which are most constant; then attempt an analysis of their actions and functions; and, lastly, make suggestions for the practical fulfilment of these conditions in our operating and work rooms.

It is a fact familiar to every dentist that the lower teeth bite inside the upper all the way round, so that a line passing through the external points of the under back teeth falls about midway between lines passing respectively through the points of the external and internal upper back teeth, and that the edges of the lower front teeth fall well inside those of the upper: nevertheless, the lower canines shut *in front* of the upper, leaving less space between them for the incisors; consequently, we find the lower incisors less than the upper.

In speaking of the relative sizes of teeth throughout this paper, it will be well to remember that only the masticating surfaces are referred to.

The lower centrals are smaller than the laterals; the upper centrals are larger than the laterals.

The lower canine, at its neck, projects more to the outside of the mouth; the upper, more to the inside.

The lower first bicuspid is either equal to, or smaller than, the second, measuring on the outside in the general line of the teeth; seldom, if ever, larger.

The upper first bicuspid is almost always larger than the second in the same direction.

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The upper bicuspids are composed of two cones or pyramids connected at the sides by transverse processes.

The lower first bicuspid has but a small inner cusp, with its anterior transverse process rudimentary.

The lower second bicuspid is almost tricuspid, the cusps much blunter than in the other teeth of this type, and with the transverse processes almost form a circular ridge.

The lower first molar, measuring in the general line of the teeth, is a little longer than the upper, often has five cusps, nearly rectangular in shape, and set with its shortest diameter at right angles to the general line of the teeth.

The upper first molar is a rhomboid in shape, the acute angle being the external anterior one, and the line of the two exterior angles parallel to the general line of the teeth. It possesses four cusps, the front internal one sends a ridge of enamel back to the posterior side of the external back cusp.

The second and third molars seem to be repetitions of the first molars, upper and under respectively, not quite so well defined, and with their cusps gradually lowering as they go back with this exception, that the farther back in the upper jaw, the higher become the internal cusps comparatively to the external; in the lower, the higher are the external relatively to the internal.

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Transverse sections show that in the lower molars the outer cusps are blunter than the inner; in the upper the outer are sharper than the inner.

In both molars and bicuspids there are running down from near the points of the cusps, enclosing leaf-shaped spaces, sundry grooves which meet in larger ones lying at the bottom of the depressions between the cusps.

From the canines to the wisdom teeth, on the inside, the distances between the tops of the cusps are either equal, or decrease as they go back; they never increase; on the outside they always decrease.

Looking from above, the articulating posterior outline of the condyle of the lower jaw appears formed of parts of two circles. The inner and larger forming part of the same circle as the symmetrical part the other side: the outer small curve forming part of an independent small circle. (See Fig. 4.)

A side view shows that the condyle articulates with the glenoid cavity so as to allow of a simple hinge-like motion, and a forward and backward motion.

Placed immediately in front of it, just under the commencement of the Zygomatic arch, is a ridge which has the effect of depressing the back part of the jaw in its forward motion. (Fig. 1.)

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In trying to analyze the relative actions of these parts I was, at first, a good deal puzzled by the consideration that possibly structural, anatomical, or rudimentary adaptations might interfere with the merely mechanical construction; but some of the facts of comparative anatomy seemed to give assurance that little would be found useless.

If we compare the central teeth of the Narwhal, or the laterals of the elephant, with those of rodents or the carnivora; the canines of the wild boar or walrus with those of man or the horse; the premolars of the feline species with those of the ox tribe; and the molars of the elephant with those of the seal; I think we shall be forced to admit that mechanical adaptation to its purpose triumphs over typical forms, or the difficulties of organic construction.

It is unnecessary for the practical dentist to inquire into the causes of several features in the human dental system.

We may assume the number of the teeth to be thirty-two, equally divided between the jaws, and arranged in two uninterrupted nearly parabolic curves, lying between the external margin of the tongue, and the lips and cheeks.

The lower jaw is possessed of a combination of both horizontal and vertical motion, which it will be convenient to consider separately.

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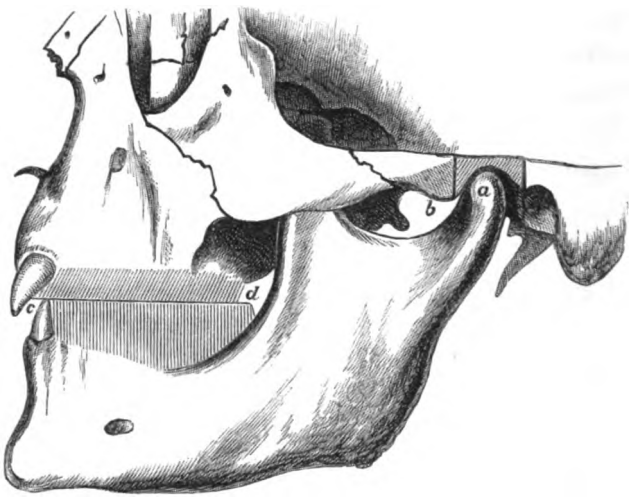
When the teeth are shut, the condyle lies at the back of the glenoid cavity, where, the front of the lower jaw being depressed, it turns like a hinge (see Fig. 1).

FIG. 1.



Side view of upper and lower jaws closed and at rest. *a*, condyle in glenoid cavity exposed by the removal of a portion of the bone at the root of the zygomatic arch. *b*, ridge in front of glenoid cavity. *c*, *d*, diagrammatic section of the plane in which the teeth meet when the jaws are at rest.

Looking at the jaw from the side, the teeth present a series of cones which so nearly alternate or lock when the mouth is closed, that it will be best, at present, to consider them as doing so.

The application of these cones to food will be most penetrating, if they close so that the points meet first, and they then slide into their places. The position of almost all the levators of the lower

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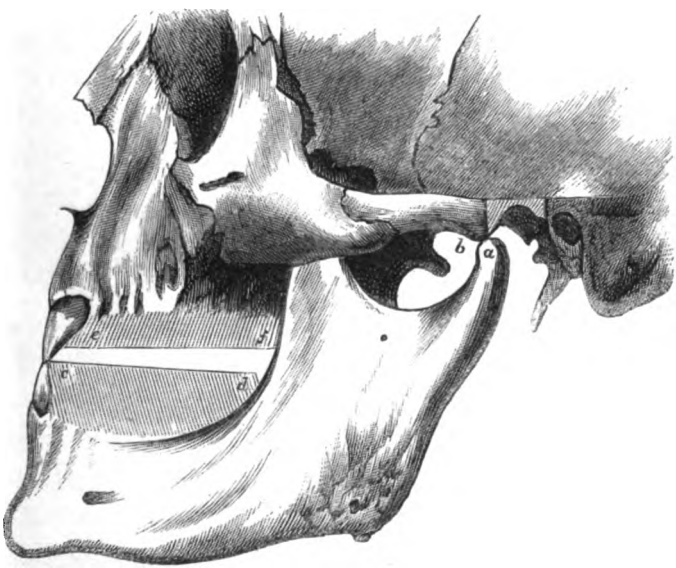
jaw passing, from its back part, backwards and upwards to the skull, will give, as the most powerful mode of accomplishing this, that the jaw be depressed, brought forward, closed and brought backwards and upwards. In this passage, from before backwards, but for some provisional arrangement, there would be great danger of the upper cusps being entangled in the lower, especially as, from circumstances to be hereafter explained, the points are not exactly

FIG. 2.



Same view of jaws as Fig. 1, with lower jaw brought forward so that the edges of front teeth meet, showing that the condyle (*a*) coming under the ridge (*b*) increases the distance between the back teeth at *d* and *f*. *c*, *d*, plane of lower teeth. *e*, *f*, plane of upper back teeth.

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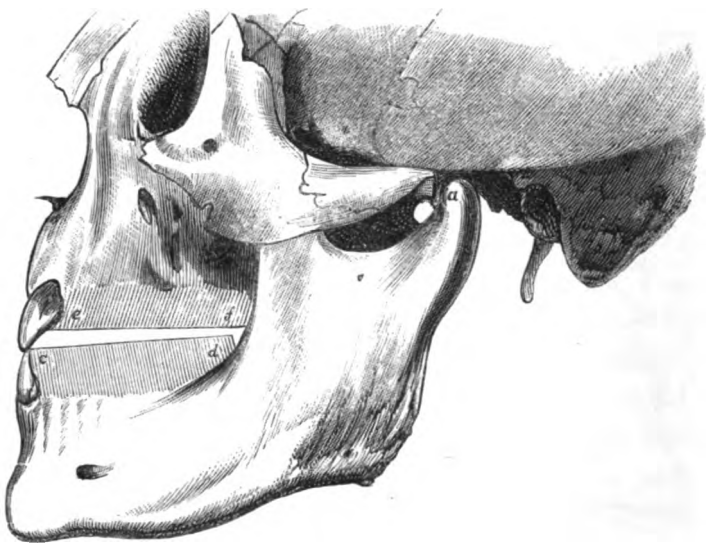
equidistant or reciprocal, there being more in the lower than the upper jaw.

The further back, from evident reasons of leverage, the greater the power, therefore, the more obtuse may be the points of these teeth; and by thus lowering them there will be less danger of their clashing. To make a still further margin for comfort, and at the same time allow a wider opening at the back of the mouth than a mere ginglymoid action of the joint would give, there is, in front of the Glenoid cavity, a promi-

FIG. 3.



Ideal position of lower jaw, if in coming forward the condyle (*b*) had traversed a line parallel to *e*, *f*, instead of being depressed by the ridge, Fig. 2, *b*, showing in this case how little would have been the space between *d* and *f*.

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nence which has the effect of depressing the back part of the lower jaw when drawn forward by the pteregoid muscles (see Figs. 2 & 3).

But this depression would not affect the under-teeth relatively to the upper unless the plane of the teeth formed an angle with the line of depression; which consequently we find in construction (see Fig. 1). It is not practicable to measure this angle in the living subject; but I have here an instrument for measuring the angle formed between the plane of two lines drawn from the articulating surface of the condyles to the top of the front lower teeth, and the plane of the teeth, which is near enough for use. Out of a few observations I find this angle to vary from twenty-two to thirty degrees. An arrangement also giving greater power to the muscles by allowing them to act more at right angles to the general plane of the teeth.

This contrivance at the back, and the lower canines closing anteriorly to the upper in front, obviates any danger of jarring; the eater in closing his teeth gets his lower canines against his upper, and all the rest must fall into their right places. The canines therefore take important positions as guideposts. May not this function explain the reason of what is nearly a universal law in comparative anatomy, that the lower canines fall in front of the upper; and also may it not have something to do with their late irruption? The teeth

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come up in such order as best enables them to adapt themselves to each other and their proper place. As an artist in drawing first dots the essential points of his picture, and then fills in the details; first come the first molars and centrals, then the laterals and first bicuspids, then the second bicuspids and canines, and lastly the second molars and wisdom teeth. If they came up in rotation from before backwards, in consequence of the longer cusps of the canines meeting and keeping the jaws apart, the molars would have longer to grow before they met, and there would have been a great probability of their getting irregular in articulation, or, from the canines having to bear unassisted the force of mastication, they themselves would be thrown out of place. In cases where this occurs we are well aware how frequently the third molar gets into disadvantageous positions.

The scissors-like action of the front teeth, and their use in cutting off pieces of food suitable for mastication, are too simple and familiar to need much attention. Wedge-shaped, I expected to find the angle of the wedge equally divided by the circle of motion, which would give the greatest dividing power; but this is not the case, the angle of the wedge points much more outward in the upper and inward in the lower teeth, reminding us that in closing the teeth, as well as an upward there is a backward motion.

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The canines, pointed as well as wedge-shaped, and from their position, a little further back in the mouth receiving more muscular force, are powerful aids to the incisors in dividing such substances as hard fruits, biscuits, crusts, and other splittable matter. A great deal more power falling to the bicuspids, they are formed, especially the upper, of two sharp cones or pyramids, capable, not only of splitting but of retaining fragments in position, until crushed by the opposing teeth. Here we first meet with a very important element, the guard. If the four cusps of the upper bicuspids of each side alone stood, they would be equally efficient in penetrating power no doubt, but fragments of food would be thrust into the interstices, and jammed there, causing wounds to the gum, or at any rate great inconvenience. A strong ridge of enamel therefore connects the bases of these cones, which act as efficient protectors to the gums against this discomfort.

The most distinguishing feature between the lion and the hyæna is found in this guard. The latter animal—a much more thorough bone-eater than the lion—is provided with a thick, sharp ridge of enamel round the base of his teeth, which shields the gums from splinters of bone that would otherwise endanger them.

The human lower first bicuspid, in which the posterior half alone is opposed to a double-pointed tooth, has a guard on that side only.

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The second lower bicuspid is composed apparently of a circular guard running round from the external cusps, and breaking up into one or two small internal cusps. I do not understand its peculiar shape; but the following considerations may explain why it, in common with the rest of the lower back teeth, is flatter on the top of the crown than the upper opposing teeth. Although it is the lower jaw which actually moves, yet from the force of gravity, and the fact that the tongue, which greatly helps in placing and retaining substances between the teeth, moves with it; the food remains on the lower teeth, and is struck by the upper. The lower teeth partake therefore more of the character of anvils, the upper of hammers; so the lower teeth are made more cupped in shape, to retain the various substances whilst struck by the upper. Add to this above, between the tongue and the palate, and not below, is evidently the place for the food when squeezed from between the teeth. Therefore channels of clearance, to be hereafter noticed, are cut principally from the upper teeth.

As before mentioned, a bird's-eye view of the lower jaw shows us that the back part of the condyles can be divided into parts of two circles (see Fig. 4), a larger and inner, whose common centre (Fig. 4, *a*) is outside the front teeth and a

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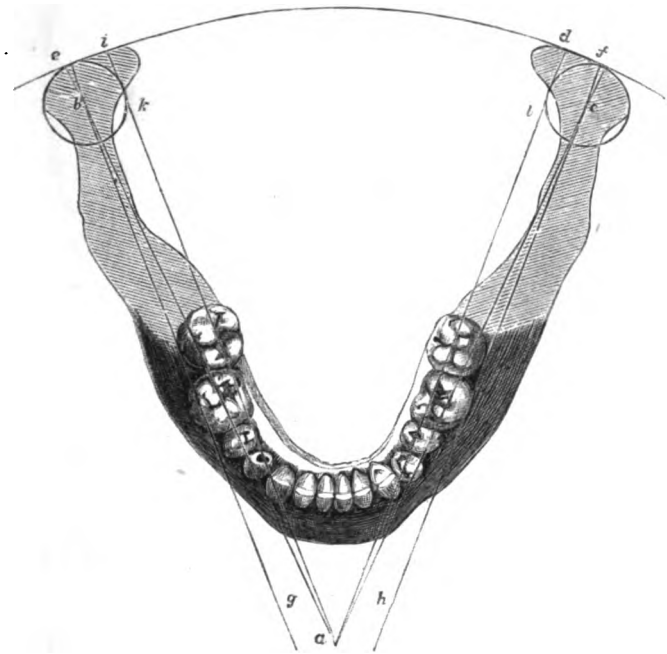
smaller outer, whose distinct centres (Fig. 4, *b*, *c*) are far behind the last of the back teeth.

FIG. 4.



View of the lower teeth and diagrammatic section of the outline of the lower jaw, looking at it from above. *a*, centre of circle, *e*, *i*, *d*, *f*, which forms the boundary of the condyles behind. *b*, *c*, centres of the two circles, *e k*, *l f*, parts of whose circumferences form the external angles of the condyles. The teeth when drawn to the left side, for instance, on that side, first move on the lines *a d*, *a c*, and then on the *a c*, *c k*, and reciprocally on the opposite side.

When the jaw is drawn to the right, by the action of the external pteregoid muscle of the opposite side, it moves for a short distance, not

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FIG. 5.

Facial part of skull viewed from below with outline of lower jaw left blank, *a c a'*, drawn to the right side by the left pteregoid muscle *b*. The white spaces, *e*, *e*, *e*, *e*, are the positions occupied by the tops of the lower teeth when at rest; the shaded spaces to the right of these show the lateral motion of the teeth from rest to the position supposed to be occupied by the jaw in the figure: the black spaces to the left show the reciprocal action when the other muscle alone acts. The shaded and black spaces on each side each blank space show the limit and direction of the lateral motion of the teeth. N.B. The alternate teeth have been omitted to avoid confusion.

more, I believe, than the width of half the grinding surface of a tooth in the large circle. On first noticing this action I was sanguine that the side teeth would prove to be arranged on the radii of this circle; and in three skulls which I have

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measured, it approximated so closely as to seem like confirmation; but I find in some monkeys' skulls, with the condyles on the same plan, the side teeth in parallel rows; so that this appears doubtful.

Whilst there is only this slight lateral motion, of course both sides will move on radii of the same circle; but by increasing the action of the pteregoid muscle the left condyle will be brought forward under the zygomatic ridge (see Fig. 2, *a*, and Fig 5, *a*), and the right will turn on the circumference of the small circle. The combined motion of the circles will thus give the right side nearly a simple lateral action; whilst the left will be moved more downward and forward at the back of the mouth than in front (see Fig. 5, *e*, *e*, *e*, *e*); thus accounting for the fact that the inside of the upper and the outside of the lower are the highest cusps in those teeth (see Fig. 7), as whenever they are opposed to any extent, the condyle of that side is depressed by being brought under the zygomatic ridge.

The forward motion which is given to one side of the jaw when drawn in, by the pteregoid muscle of that side only acting, will also explain the use of the ridge of enamel traversing the crown of the upper molars in that direction; but this I shall enter on more fully directly.

It is evident that for one curve to move for-

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wards, backwards, and from side to side, within another curve, the inner curve must be the smaller, because we make it retreat an equal distance each side and in front; that is, we cut off it twice as much from the sides, as we do in front. The lower front teeth, therefore, must meet in a sharper curve than the upper, and this may explain the relative difference in width of the central and lateral incisors between the upper and under jaws; for if we place lines, representing the relative linear width of these teeth, at equal angles, we shall find those representing the upper teeth make a bolder sweep than the others; though in opposition to this suggestion it may be urged that the kangaroo has large centrals with a very contracted arch, and some monkeys have the lower central teeth larger than their laterals.

The cusps of the lower teeth commencing to alternate in front of those of the upper, would leave, if there were an equal number in the two jaws, the posterior part of the last upper tooth unappropriated (see Fig. 6). To obviate this difficulty there is a rather complicated arrangement. The bicuspids are too small and simple to allow of much trimming. In the molars the inner cusps alternate above and below; but in the first upper the external posterior cusp is brought forward a little, and as it would then encroach too much upon the anterior cusp, that

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is brought forward too, diminishing the external face of the second bicuspid somewhat, and giving the molar its characteristic rhomboidal shape.

FIG. 6.

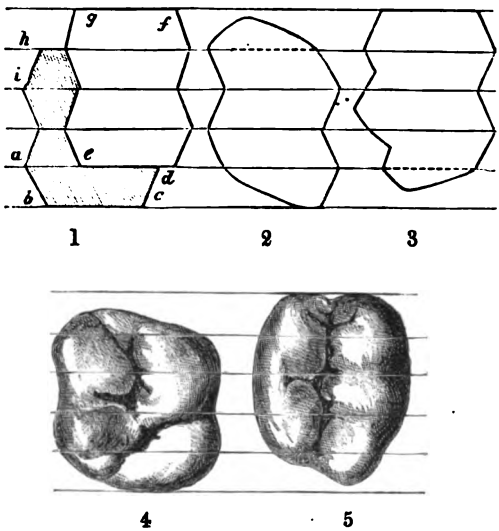

Diagram to explain the particular form and articulation of the upper and lower first molars :—

No. 1.—Ideal diagram of the surface of a lower molar, *g e d f*, in position upon an upper, *h b c*, showing that if the cusps simply alternated, the part of the upper, *a b c d*, would be unoccupied.

No. 2.—Masticating surface of upper molar, showing how the external cusps are brought forward.

No. 3.—Masticating surface of lower molar, showing how the lower molar is extended back by the addition of an extra cusp.

Nos. 4 and 5.—Masticating surfaces of upper and lower molars of the left side in their relative positions, showing that the fifth cusp of the lower would fall just behind the transverse ridge of the upper.

The forward cusp of the upper molar being

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outside and rather flattened on its masticating surface, does not interfere with the corresponding part of the lower; but the second outer cusp, from a cross ridge to be considered directly, does; so its antagonizing cusp on the lower jaw is shortened up, and makes room for a small third cusp to be wedged in (see Figs. 5 & 6). By this means the upper teeth are shortened on the outside range, and the under ones lengthened. This fifth cusp of the lower molar locks behind the transverse ridge of the upper molar, which we may remember passes from the outside of the back of the tooth forwards and inwards, the direction taken by the lower jaw when the pterygoid muscle of that side alone acts (see Fig. 5), as before mentioned. In this action the fifth cusp of the lower jaw glides along this ridge.

The second and third molars repeat the arrangement in each case, the lower molar gaining a little on the unoccupied space, until, in the third molar, the back of the upper and lower ranges of teeth are terminated by the same line.

If two opposing teeth be hollowed in their centres, to retain food whilst it is being crushed, their cusps exactly alternating, the resistance made by any substance to their closing would be immense, because it would be confined.

There are, therefore, channels of clearance cut between the cones of all the molar teeth, and

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from the centres to the out or insides of the bicuspids. The food would squeeze equally through these if of equal size; but we do not want it forced under the tongue, so these grooves are much wider and deeper in the upper than the under teeth, the upper are rounded off, do not fit so regularly, and have larger interstices invading them from the cavity of the mouth.

It is important that the dental organs should be arranged so as to keep sharp as long as possible: among the lower animals we find many ingenious contrivances for this purpose; that of the front teeth of rodents is well known. Two very opposite methods are well illustrated by the kangaroo and lion. In the latter the two great carnassial teeth are placed like shears longitudinally with the jaw; each opposing blade is trenched into a waved notch, so that bones or pieces of flesh placed between cannot slip forward when bitten. In these teeth the external side of the upper and the internal of the lower slope off, and a deep groove corresponds to the angle of the notch; thus as they wear they sharpen each other and maintain their shape. In the kangaroo the molars are divided into a series of transverse cutting blades, adapted for chopping into short lengths the vegetable food on which it subsists. These blades have nearly the same shape as the carnassial teeth above mentioned; but their form is maintained in a different manner.

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At the bottom of the hollow between the blade, at the extreme reach of the opposing tooth, lies a longitudinal ridge, which, by wearing the edge of the tooth which meets it rather more in the middle than it is done elsewhere, keeps it in a hollowed shape.

This requirement is partly met in the human economy by the bulging form of the cusps, which, by this form, to a great extent saves their points from friction or concussion; and by the enclosed edges which have to resist the direct force of the bite being made more obtuse than the free edges. Thus the inner edge of the upper molars and the outer of the lower are much blunter than their respective opposites (see Fig. 7).

In entering upon the consideration of how best to make dental substitutes satisfactorily fulfil the functions of teeth, it will be convenient to divide the masticatory elements into five heads.

1st. *Elements of Free and Easy Articulation.*— The teeth are to be allowed free motion, up and down, from before backwards, and from side to side, without jarring or entangling the cusps.

2nd. *Elements of Pure Mastication.* — The crowns of the teeth are to have such forms as are best adapted for dividing, splitting, and crushing the food.

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3rd. *Elements of Protection to the Gum.*—The gum is to be guarded from injury or annoyance by the food being wedged between the teeth.

4th. *Elements of Clearance.* — Channels of escape are to be made in the teeth, so that they do not choke with the food, but squeeze it out into the most convenient place.

5th. *Elements of Sharpening.* — Arrangements are to be made for maintaining the teeth in an efficient state of sharpness.

An essential part of carrying out these conditions in artificial teeth, is to have an accurate bite. This is not always an easy thing to obtain.

With as good a bite as I can get, I strike up the plates, mount the central teeth on each and put on side blocks of deal, with sealing-wax, to carry the springs.

Having made an appointment with the patient for the purpose, the bite is now rectified. If either piece is for vulcanite, it is modelled in gutta-percha instead. I am indebted for many valuable hints connected with this method to Mr. Wm. Cattlin, and find it very advantageous.

There seem no guides, but the lips and expression, to regulate the height of the bite, and the relative height of the upper and lower teeth. The front teeth should be so placed that the lips close

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without pouting or being strained, without projecting or falling in.

I think the upper and under front teeth should about equally divide the space between the lips when the mouth is opened so that their edges meet. Yet we often see cases where the upper teeth and gums alone are visible, rarely with the lower teeth more conspicuous.

The upper front six teeth will probably be chosen on principles not immediately the subject of this paper. The lower front six should then be taken of such a size that the canines will shut with their points a little behind the lines between the upper laterals and canines.

Unfortunately, on dental plates the power does not increase as we go backwards; the end of the base would be pressed heavily into the gum if we expected it: this, with the fact that the ascending process of the lower jaw seldom leaves room, makes it advisable to omit the third molar. The eight bicuspids should be the same width. The two first lower molars may be rather wider than the others, which should be equal.

Some of the profession, I believe, make their own teeth, and it would be easy for them to carry out the elements of mastication, relative to the forms of the tops of the teeth, in a much more efficient manner than I have been able to do. But most, I believe, use manufactured teeth, and it is one of the objects of this paper, that if this

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Society indorses my belief in the need for them, the manufacturers might be induced to supply improved forms in back teeth. The upper canines, too, we want a good deal deeper from the labial to the lingual surface for the lower to run against as guide-posts.

Having chosen the front teeth, arrange the upper six according to the arch of the mouth and taste, and mount the lower six in a smaller curve, so that they bite within the upper. Mark the spot on the plate it is intended to carry the teeth back to—say within one-third of an inch of the ascending portion of the lower jaw—and choose back teeth, in the before-mentioned proportions, to fill up the space; let the first bicuspids continue the arch with the front teeth, and place the others in a straight line back to the mark. The last tooth in the lower will probably fall rather to the inside of the remains of the alveolar ridge; but this is another point for which I can find no definite guide.

By means of this bite-frame, which has been shown to the Society before, the teeth can be placed in the right plane. The angle which the plane of the lower gums forms with the plane of straight lines drawn from the condyles to the front of the gums, is measured; also the distance of the front of the gums from the condyles.

The lower model is then placed in the frame, in the same position relatively to the centre of the

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hinge; and the upper is fixed in the top saucer of the frame, according to the rectified bite previously taken.

The lower back teeth are now mounted, and let down so as to make the angle of their plane, with that drawn to the condyles as before mentioned, as nearly twenty-six degrees as convenient.

To fulfil the second conditions, those of giving the best masticating surface to the teeth, cut away the front half of the inside cusp of the lower first bicuspid, and make as clean a notch as possible into the top, leaving the inside cusp much lower and blunter than the outside; then carry the wheel round to the back, so as to leave a guard a good deal lower than the cusp. The second treat in the same manner, leaving two guards. The upper bicuspids divide more deeply and equally, but still leaving the outer cusps sharper and higher than the inner.

Among other notable differences between an ordinary porcelain molar and a natural one, we shall notice that, whereas the distance between the points of the outer and inner cusps of the natural one is scarcely ever more, often much less, than two-thirds the thickness of the body of the tooth, in the artificial tooth the top, we will not speak of its cusps, is very nearly as wide as any part (see Figs. 7 and 8), thereby incommoding the tongue, thickening the speech, and requiring increased power to force it into food. Having less,

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instead of greater, power on plates instead of fangs, I have found it advantageous to bring in

Fig. 7.

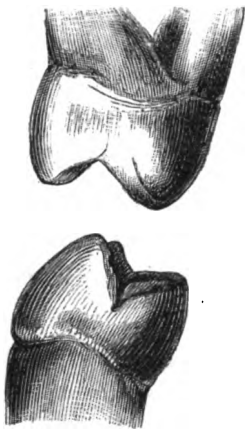
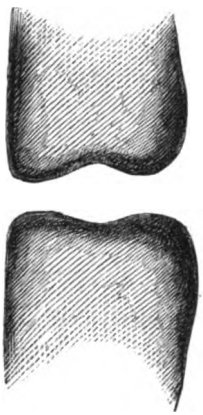


Fig. 8.



the width of the tops of the molars to half that of their crowns, taking it principally off the inner side of the upper, and the outer of the lower teeth. Now cut a deep furrow as sharp as possible, dividing the tops of the teeth longitudinally, and passing rather nearer to the inside of the lower and the outside of the upper, and leaving the inside of the upper and the outside of the lower the higher sides of the teeth. Cut a similar notch across the middle of the lower molars and take a little off their ends, so as to leave pyramids having their angles, except their points, a little rounded. The upper molars should have their anterior inner and posterior external angles rounded off somewhat so as to give their faces

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a rhomboidal form, and they should then be cut into cusps, similar but a little sharper than the lower.

The teeth may now be mounted to the bite, the lower cusps falling into the same places relatively to the upper as in the natural organs as before described.

If there seem not to be sufficient channels of clearance, enlarge them by rounding yet further the anterior inner angle and cusp of the upper molar and deepening the divisions between the cusps generally in the upper set.

Porcelain teeth are so hard that there does not seem any necessity to pay further attention to means for preserving them sharp; and the base on which they are mounted generally serves as sufficient protection to the gums.

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GENERAL MONTHLY MEETING.

Monday, November 5, 1866.

W. A. N. CATTLIN, Esq., President, in the Chair.

The following Gentlemen were duly elected Members of the Society:—

John Saxty Good, L.D.S., 17, Lower Phillimore Place, Kensington.

Horatio M. Jones, 3, St. John's Hill, Shrewsbury.

The following Gentlemen were proposed for the Membership of the Society:—

Robert F. H. King.

Henry Bell Longhurst, L.D.S.

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A Paper from Dr. M'Quillen, M.D., D.D.S., of Philadelphia, was read by the Secretary :—

Mr. President and Gentlemen,—Several years have elapsed since you honoured me by an election as a corresponding member of your Society. While recognizing in such action that an obligation had been imposed upon me to contribute something to your Transactions, I have been prevented by various and pressing duties from consummating that which my inclination has constantly prompted me to fulfil. In addressing you now for the first time upon a scientific subject, I offer you in writing some oral remarks made by me recently before the American Dental Association, at the meeting held at Boston.

I should be pleased to send my microscopical specimens along with this, but I doubt not some of the gentlemen present at the meeting will have specimens in confirmation of my statements. Should mine be required, however, I shall be happy to forward them. My remarks were as follows :—

Your attention is desired during a brief period, for the purpose of bringing under your notice a subject which is not only interesting when viewed from a scientific stand-point, but also of decided importance on account of its practical bearings; I allude to the *interglobular spaces in dentine*. Although long familiar with their existence in that tissue through the researches of Owen, Tomes,

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Czermak, and Kölliker, it is only within the past few months that I can claim to have given to them that careful consideration which they so justly merit. Some investigations which I have recently prosecuted in this direction were prompted by a desire to become more familiar with the subject; and as the microscopical examinations instituted by me, and the conclusions arrived at, are fresh in my memory, it is possible that their presentation may be of service to those who have paid no attention to the subject, and particularly to some before me who are labouring under erroneous impressions with respect to the exact character and position of these spaces.

To the best of my knowledge, no American observer has as yet placed on record any evidence of a careful examination of these spaces. In an oral address which I had the honour to deliver last fall, in New London, by invitation of the Connecticut State Dental Association, on the "Microscopy of the Dental Tissues," the attention of those present was directed in a very brief manner to the *interglobular spaces*. Subsequently, when publishing that address in the Dental Cosmos, an illustration from the American edition of "Kölliker's Microscopical Anatomy" was used, with the view of making the general appearance and position of these spaces more easy of comprehension on the part of readers. That engraving has been very decidedly objected to, by one

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who claims to have some knowledge of histology, and in the use of the microscope, as erroneous, and with the assertion that the appearances there presented are either due to the presence of air-bubbles formed in mounting the section in Canada balsam, or to a mistake on the part of the engraver. My response to this is that I would not think of charging the merest tyro in the use of the microscope with being so easily beguiled, let alone such a careful and accurate observer as Kölliker, and that any important errors on the part of the engraver would have been noticed by that author, and promptly corrected by him while the work was passing through the press.

Up to the time when these objections were brought to my notice, notwithstanding the fact of having prepared a large number of sections of teeth and bone, and examined a number prepared by others under the microscope, I had not been fortunate enough to find a specimen in which these interglobular spaces were present. Determining, however, to thoroughly investigate the subject, I made a number of sections of teeth which had been recently extracted; and in one, from a first permanent inferior molar, was fortunate enough to find the object of my search. The evidence of this is before you in one of two large and excellent diagrams by my friend Mr. Petit, an artist of Philadelphia. The first of these presents a faithful portraiture of a portion

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of dentine with the *interglobular spaces*, the other showing the appearance of a section of bone with the lacunæ and canaliculi observable in that tissue. As I have with me the sections from which these drawings were made, along with a number of others, of the teeth of man and animals, it would afford me much pleasure to show the preparations to those who may desire a view of them under the microscope.

With these preliminary remarks, as it is foreign to my purpose to enter into a detailed consideration of the dental tissues at this time, it will suffice to state in a general way that human dentine is composed of an immense number of microscopical tubes, the *dentinal tubuli*, and a *matrix* or *intertubular tissue*, which presents a homogeneous appearance under a lower power, but when highly magnified is found to be made up of minute granules united closely together. The *tubuli*, commencing by open mouths on the walls of the pulp cavity, may be seen passing in a radiated and a slightly wavy manner towards the periphery of the dentine, where they terminate in the intergranular spaces of Tomes, or pass on into the enamel or cementum. In their course they divide dichotomously, and give off small branches from their sides which inosculate with each other. Any one who has the slightest familiarity with the microscope is well aware that the calibre of the tube decreases in size when passing from the

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openings on the walls of the pulp cavity to their terminations at the periphery of the dentine; this is due to the fact that as calcification of the structure progresses from without inward, the portion first formed necessarily contains the largest proportion of inorganic matter, owing to a law in the economy that tissues increase in density with age. This is markedly illustrated in the entire obliteration of the *dentinal tubuli* by calcareous depositions within their parietes, as frequently presented in the teeth of old persons. In the coronal dentine, a number of faint lines are often found passing in an arched manner from one side of the

FIG. 1.—Section of Dentine with *interglobular spaces.**

section to the other, and at right angles with the dentinal tubuli. These are named after their discoverer, the *contour lines or markings of Owen.*

* The illustrations accompanying this communication are from the specimens prepared by me.

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They are not confined exclusively to the crown, but may be frequently observed in the roots.

In teeth perfectly formed, the appearances thus hastily described as characteristic of human dentine are invariably presented. In addition to this, the peculiar spaces already referred to as *interglobular spaces*, are sometimes observable in the neighbourhood of the enamel (as in the section from which this drawing was made, see fig. 1); *but they are by no means invariably confined to that locality*, for in some specimens they are *scattered in great profusion throughout the coronal dentine*,* and in other instances they are found in the roots, particularly of deciduous teeth. These spaces do not present a globular or spherical shape, but on the contrary are very irregular in their form; and although sometimes quite small, are more frequently long and wide, and include a number of tubuli: the name applied to them, therefore, would seem to be a misnomer. On examining the boundaries, however, it will be observed that they have a notched appearance, and are made up apparently of a number of sections of globules: the

* This is markedly the case in a specimen prepared by Burgogne and Alliot, of Paris, which my friend Dr. W. S. Bowdoin of Salem, Mass., placed in my hands the day on which this communication was made to the Association. Having described the appearance of my preparation to him the evening before, he said that some microscopical sections imported by him from France had just been received, and he would like me to examine them. The one referred to was among these, and is a very valuable specimen, particularly in illustration of these spaces.

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propriety of the appellation thus becomes quite evident. The *tubuli* do not generally stop at the boundaries of the interglobular spaces, or turn so as to pass along their sides; but they can be readily seen passing directly across them. I direct attention in particular to this fact, as it has been positively asserted that the tubuli never pass through these spaces. They are not as well defined there, it is true, as in perfect dentine; but this is easily accounted for when the exact character of these spaces is fully understood.

FIG. 2.—Section of Bone, with *lacunæ and canaliculæ*.

With a view to this, we will push our inquiries in that direction. In the first place, it has been inferred by some persons that the *interglobular spaces* are *cavities*, like the *lacunæ* of bone; but the fallacy of this view becomes readily apparent on examining this drawing of a section of bone (see fig. 2), and comparing it with the other. In

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it will be observed a large number of dark lenticular-shaped spaces, with several irregular lines passing from each of them, scattered in great profusion over the entire field, and bearing no resemblance to the *interglobular spaces*; but, on the contrary, not unlike spiders in their shape. Purkinje, who first observed these, regarded them as *bodies*, and he therefore named them *corpuscles*, and for a long time they were called the *corpuscles of Purkinje*. It was eventually found, however, that they are cavities occupied by the *liquor sanguinis* of the blood in life,* and that the apparent lines passing off from them are *canaliculi*, or canals, which inosculate with each other, and serve to carry the nutrient fluid to every part of the tissue. In microscopical specimens of bone, the *lacunæ* and *canaliculi* are either occupied by air or Canada balsam, which by transmitted light gives to them a black, solid appearance, and it was this that led Purkinje astray. Now in place of the *interglobular spaces* being *cavities* filled with liquor sanguinis during life, they are occupied by a *cartilaginous structure analogous to the organic basis in which dentine is formed*, but which, unlike that, owing to some defect in the assimilative process, has failed to *undergo calcification*. The tubes running through them are not as well defined as

* Dr. Lionel S. Beale, in his work on the "Structure and Growth of the Tissues," says "that the *lacunæ* are occupied during life by a soft substance which he calls germinal matter.

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in dentine, owing to the absence of the calcareous matter, which in the latter brings out the parietes of the *dentinal tubuli* in a sharp, well-defined manner. The presence of these tubes, however, in the *interglobular spaces*, in a section from a first permanent molar recently extracted, can be made readily apparent to those who will take the trouble to prepare and carefully examine such a specimen. The cartilaginous structure occupying these spaces, however, eventually dries up, and a section taken from a tooth some time after removal from the mouth would have actual cavities in it, which, when viewed under the microscope by transmitted light, would present a black appearance like the *lacunæ* of bone and cementum. This, without doubt, was the case in the specimens examined by that accurate and indefatigable observer Mr. Tomes, whose investigations with the microscope have done more than any one else to establish clear and accurate views of the minute structure of the human teeth, and whose observations have been so highly and justly prized by the scientific world that they are quoted as reliable authority in the works of the most eminent anatomists and physiologists of the present day. The illustrations of the specimens referred to are to be found in his "Dental Physiology and Surgery," published several years ago, in which he directs attention to peculiar-shaped cavities which he observed as quite numerous in carious teeth lost early in life,

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particularly the first permanent molars. As he makes no reference in that work to the appearance of the *interglobular spaces*, with the cartilaginous substance present in them, it is probable that they escaped his notice up to that time, from the fact of having made his sections from teeth some time after they had been extracted, in place of those recently removed, and in which the cartilaginous substance had dried up, and left actual cavities, as he correctly regarded them.

In conclusion, as evidence of the practical bearings of these investigations, it may be well to direct attention to the fact that the existence of these spaces in teeth which have completed their growth must be regarded as an *abnormal condition, predisposing* such teeth to decay, and that when either by mechanical action, as by a fall or blow, or by the penetration of external caries, such spaces are reached, the *disease here would run riot.* Hence the importance of care, on the part of patient and operator, to have the most minute external cavities filled, for though reached only through a microscopical opening, the result would be the same; while if protected from the action of external influences, or the *exciting causes of decay*, this *predisposition* might remain dormant for a lifetime, as is sometimes the case with disease in other organs of the body.

These spaces, however, cannot be looked upon as *abnormal*—as, for instance, when existing in

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young and growing teeth, the arrest of calcification may be remedied subsequently by the assimilative process, as the soft bones of children eventually become strong and hard by the deposition of a due proportion of inorganic matter. It is reasonable to infer that the obliteration of the interglobular spaces in growing teeth assists in giving to dentine the peculiar markings named *contour lines of Owen*. The spaces becoming occupied by calcareous matter, their boundaries form the contour lines, and remain as permanent evidence of the former existence of the spaces. In addition to this, the primary curvatures of the dentinal tubuli contribute toward that appearance.

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The Secretary then read the following Paper:—

Remarks on Indian Dentistry—Absence of Caries—Use of Tembul or Pawn—The Toilet and Dentifrices in use among the Natives of Southern India. By John Short, M.D., F.L.S., M.R.C.P.L., &c., General Superintendent of Vaccination, Madras Presidency (late Zillah Surgeon, Chingleput).

Mr. President and Gentlemen,—India, like England, has had its priests or monk-physicians, barber-surgeons, bone-setters, midwives, and herbalists, and among these dentists were not wanting to make up the category of professionals. Believing it would prove interesting to describe briefly these different professions as they existed in India, and are now slowly disappearing in most stations before Western science and enlightenment, I am prompted to put these few notes together.

Hindoo priests and monks of various sects, styling themselves *Sunniasees*, *Byragees*, *Fakirs*, with other religious mendicants, have from time out of memory held sway over the minds of the masses of their more ignorant fellow-creatures. By their pretended piety and holy vocation they were believed to have a control over the mysteries of Nature; and by exorcism and magic, spells and incantations, prayers and sacrifices, and sometimes by drugs, they were reputed to be all-

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powerful in the cure of diseases. This body has gradually given way to a class who in India style themselves *Vythians*, and, if followers of the prophet, *Hakeems*. Among the Hindoos, there are a few who are supposed to be learned, and to have studied the medical shastras; among the Mahomedans, some have had access to works of Arabian physicians and Greek translations. The former feel the pulse, and by its indications alone foretell diseases; whilst the latter have recourse, in addition to the pulse, to the inspection of urine, which they pretend to understand, and thereby discover and treat disease. Barbers and surgeons, like their brethren of old in England, were renowned amongst their countrymen for their skill in the chirurgeon's art. They performed venesection and other minor operations: some few cut for stone in the bladder, and others have even successfully extracted cataracts. Their knowledge was simply practical; they were utterly innocent of anatomical lore or theory of any kind; but from the attention they devoted to the subject in practice, it is not surprising that their surgical performances should not unfrequently have turned out successful.

Bone-setters belong to the class called pot-makers—this being their legitimate trade. They were supposed to be masters in all relating to bones and their injuries, and were said to be great experts not only in detecting, but reducing frac-

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tures and dislocations, which they accomplished in the same offhand way in which they fashioned lumps of clay into a variety of utensils,—ornamental as well as useful. Unfortunately for this class, from not understanding anatomy, nor the theory of the circulation of the blood, they frequently did more harm than good. By their tight ligatures, and rude bamboo splints, the circulation of the disabled limb was often arrested, and terminated in gangrene; and fortunate was the individual if he succeeded in saving his life with the loss of a limb.

The class of midwives also pertained to the barber tribe. Whilst their lords and masters were professors of surgery, the ladies were said to rule supreme in the obstetric art. Although other classes of women practised midwifery, they were never supposed to approach to, or command the knowledge brought to play in such cases by the barber women; and in every instance of difficulty occurring in labour, the barber women were immediately called in, should their services not have been already availed of.

The herbalists, generally the most rude and half-wild tribes found inhabiting the outskirts the village, however ignorant they may have been in other matters, were allowed to be surprisingly skilful in recognizing the various herbs and drugs, and in predicating their healing virtues; and as most of these people led a nomadic life, and

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roamed chiefly in jungles, it was said, Who could understand the subject better than they ?

And, lastly, we turn to that particular class whom this paper more especially concerns—the dentists or the goldsmiths of Southern India—who, from their mechanical skill and art, were naturally led to practise dentistry, in which they were supposed to be masters. Their knowledge in this art was simply practical. By the mechanical skill acquired in their more legitimate trade, they were enabled to fasten loose teeth by fine gold wires, so as to give them a stability in the mouth, and occasionally fixing one or more false teeth, when needed, by means of a plate of gold. The tooth or teeth, in such cases were simply riveted to a cross-bar of gold, having claws at either extremity, which were fastened on to the adjacent sound teeth, and thus retained in their new sockets. The false tooth so fastened was often a human tooth, or, in the case of incisors, sheep teeth were frequently inserted as substitutes. This fact first came under my notice by observing an officer wearing a false tooth. The fit of the substitute was excellent, and had it not been for the head of the nail riveting the tooth to the plate of gold being visible, I should never have been able to detect it. I was further surprised to find on subsequent examination, that the tooth used in this instance was that of a sheep. The officer alluded to, met with an accident, whereby he lost

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one of his lower lateral incisors. His drill havildar, or sergeant, suggested and produced the goldsmith who fastened on the substitute so artfully. In native regiments the non-commissioned native officers frequently have recourse to the art of the goldsmith in the way of dentistry. These native gentlemen, in their solicitude to preserve a juvenile appearance as long as possible, seek the aid of the goldsmith on all occasions when any of their teeth become loose, or in the event of any of them dropping out. The natives, as a class, do not suffer from caries of the teeth. I have examined many mouths of all ages, expressly, and others who have sought my assistance for some tooth affection or other, but in all my experience I have never seen caries amongst natives. The entire immunity in the natives of this country, from this affection, has been attributed to the constant habit they are addicted to, of chewing the *pawn*, or betel-nut. In England it is well known, that the "venom'd stang" has ever been, and still is, the greatest plague to all ages and classes; it would assuredly, therefore, be interesting to explain here what the *Tembul*, or quid of betel, comprises, to which this enviable immunity from the "hell o' a' diseases" has been ascribed. It consists, in the first place, of from three to five leaves of the chavica betel. Each leaf is folded on its outer surface lengthwise: after having the remains of the petiole and midrib removed, it is then smeared

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over with from five to twenty grains of chunam, or prepared quicklime, and the leaf is doubled on itself several times into a roll, and introduced in succession into the mouth, followed by two or more slices of the areca-nut. Some people add to this a small piece of tobacco; others use a little of the acacia catechu. The areca-nut for this purpose, is prepared by slicing, boiling, and subsequently drying in the sun. Natives of wealth and rank make use of spices and other ingredients, in conjunction with the betel-nut. This compound, after being well masticated, is constantly retained in the mouth, occasionally shifted from side to side—the mass forming a visible and prominent projection of the cheek on the side where it is kept: it is renewed several times in the twenty-four hours. This compound is both a powerful stimulant and astringent, acting most energetically on the salivary glands, producing in a very short time an abundant flow of saliva, which is spit out freely from time to time. The natives believe that the betel quid stimulates digestion and sweetens the breath; but from its excitant action on the salivary glands, it tends to diminish the perspiratory action of the skin, though it allays thirst. The practice is almost universal; few natives are to be seen without it, and many will forego a meal rather than miss a quid. Abstinence from its use in those who have been long accustomed to it, is said to produce the most uneasy sensations.

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Among others, dryness of the mouth and fauces, thirst, an indescribable feeling as if something was wanting, inaptitude to work — in short, all the feelings described are analogous to those experienced by the tobacco-smoker under a similar deprivation. The ultimate results of this habit are still more serious, for whilst it undoubtedly preserves the teeth from what is termed caries, it acts most prejudicially in other ways. By causing absorption and shrinking of the gums, premature loosening of the teeth occurs, and eventually these organs drop out, or great pain and uneasiness are produced by the loosened teeth, and relief is sought ere long in extraction.

It also grievously discolours the teeth, and this is effected by the action of the quicklime on the juice of the betel, which it reddens during the masticatory process; the saliva also soon acquiring the same red colour, stains the teeth and lips, and eventually renders the teeth quite black, which to the European eye is extremely unsightly, but not so to the native, for black teeth and cherry-red lips caused by the betel quid, is a point of beauty with him. Teeth are otherwise stained black by most natives. It is incumbent on the Mussulman that he should stain the crevices of his teeth black with the *soorma*, or black oxide of antimony, immediately after marriage. Other natives also resort to this practice, more especially if anything goes wrong with the gums or teeth; and soorma

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is the remedy in general use for all such occasions. A class of natives who inhabit the Shevaroy Hills dye their teeth red, by means of the gum-lac. The teeth are covered over with the gum-lac, cotton, and sweet oil, and the individual then lies exposed to the sun, with his lips apart, and in the course of a couple of hours they attain a blood-red colour. The teeth of the natives of India when not stained by betel or other applications, might be envied on account of their whiteness and beauty; and the darker the skin, the whiter the teeth show—so much so, that they may rival, for brilliancy and whiteness, those of the negro. But it is a rare thing to see white teeth among natives, owing to the habit above described. I am happy, however, to be able to say that the betel-nut is now being eschewed by some of the more intelligent classes, from frequent commixture with Europeans, and in all such cases they are found to possess beautifully white teeth, which, I must certainly confess, adds greatly to their personal appearance. The natives themselves admire large and prominent teeth; according to a Tamil proverb, large teeth are compared to diamonds, while small teeth are called harlots. Supernumerary teeth or irregularity is not noticed; on the contrary, an individual so deformed is said to have received a divine birth, or *diva poorpoo*, and seldom will a native permit of such defects being interfered with when an

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opportunity for so doing offers. At the same time, good sound teeth are no less esteemed, than loss of teeth is deplored by them, and no individual, minus one or more teeth, can study, or practise the magical delusions of the East; and in instances where the black art, or *Jadu*, is practised to the injury of another, by witchery or otherwise, the first thing done when they get hold of the guilty individual, is to knock out his front teeth; and this they will do at any risk, for then only is the individual said to be rendered helpless, nor can he again, after such a defect, successfully resume his black art. Murders are frequently committed in their desperate struggles to effect this object.

It may not be out of place to mention here a few words descriptive of the morning toilet of a native. This is a most simple ceremony generally, but one which is most punctiliously observed. Negligence on this point amounts almost to a crime, and few natives will breakfast, or enter upon any of their daily routine pursuits or avocations, without first cleaning their teeth, to which part of the toilet the most elaborate care and attention is paid by every native. Any river-side tank, or streamlet, answers for this purpose. Long before going to the water's edge, the process of cleaning the teeth is begun; in fact, it is almost the first thing a native thinks of, and performs on rising daily from his bed. They have

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several ways in which they clean the teeth. The most common, is that of employing twigs, which for the nonce are extemporized into a sort of brush, by chewing one end, and using them just as the toothbrush is used by more refined nations. These twigs are selected from trees known to possess astringent or other qualities. Among others, the Neem tree (*Azadirachta Indica*), Babool tree (*Acacia Arabica*), rough chaff flower shrub (*Achyranthes aspera*), and the cereal roots of the Banian, or *Ficus Indica*, are most esteemed on this account. The natives ascribe various properties to the sap of these trees. That of the Neem tree, they say, is not only a deodorant, but it also whitens the teeth, and is very much valued for this reason. The sap of the Babool and Banian trees is believed to contain the property of strengthening the gums, and so also is that of the other plant mentioned. In parts where these trees are not indigenous, the twigs are sold in the bazaars. The lower orders of the people use various substances in the way of dentifrices; such as charcoal of various kinds,* cowdung ashes, brick-dust, powdered areca-nut, &c.; and when these are used, the forefinger is made to serve in the place of the toothbrush, after the substance has been reduced to a powder between the teeth. After cleaning the teeth in either of these modes, the mouth is well rinsed out, and subse-

* The charcoal from the cocoa-nut shell is greatly esteemed.

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quent ablution of the face and feet, completes the ceremony.

Native children do not generally suffer from dentition, and when they do, the cause is never recognized as being connected with the irritation caused by teething, either by Vythians or Hakeems. Native mothers look forward anxiously to the period of teething, and certain ceremonies are carried out on the occasion of the first teeth making their appearance; among others, that of feeding their friends and relatives with sweets made in imitation of the tooth, with rice boiled in milk and sweetened. Another kind of cake of a larger size, and similar composition, is also made, and poured over the head of the child, whilst other children are allowed to scramble for it. The child is made to sit on a mat, or in the lap of some superannuated female relative or friend. A sieve is interposed to protect the child's head while the cakes are being thrown on. This is the only ceremony that I am acquainted with, that is practised in connection with the teeth.

There is a belief amongst natives, that the teeth have been known to grow sometimes in very aged people, *after* the period of senile shedding, but this I imagine to be nothing more than a deceptive resemblance to teeth, caused by absorption of the gums, and exposure of the alveoli, at some prominent part of the jaw.

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GENERAL MONTHLY MEETING.

Monday, December 3, 1866.

W. N. A. CATTLIN, Esq., President, in the Chair.

The following Gentlemen were duly elected Honorary Members of the Society:—

John Flint South, F.R.C.S., Blackheath Park.
James Luke, F.R.C.S., Maidenhead Thicket, Berks.
F. Carpenter Skey, F.R.C.S., 24, Mount Street, London.
Samuel Ghrimes, Maidenhead, and Nice, Italy.

The following Donations were made to the Society:—

Mr. J. S. Turner. The model of a case of Epulis which had occurred in the practice of Mr. Campbell de Morgan.

Mr. Rymer. Model of complete osseous union between a lower second molar and wisdom-tooth.

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Mr. R. Hepburn read a Paper on—

Hard Rubber.

Mr. President and Gentlemen,—In considering the subject of Hard Rubber or Vulcanite, as it is termed, we will first endeavour to notice, both theoretically and practically, the adaptability of this material to the purposes of artificial dentistry, particularly when used as a substitute for gold, bone, or any other of the metallic, animal, or vegetable substances usually employed by us as bases for our artificial work. In calling your attention to this material, I feel I am bringing before you a subject of considerable interest to all students of our art, for, from its general adaptability to dental mechanics, it seems destined to surpass in usefulness many other substances we employ.

Unvulcanized rubber, gutta-percha in various forms, and other plastic substances, mineral and vegetable, have been from time to time introduced with various degrees of success. All these have taken their legitimate place in the dental laboratory, and are made use of only in exceptional cases; but the vulcanite continues to extend the sphere of its usefulness, as even the most prejudiced amongst us now make use of it.

Of the different materials which have been brought under the consideration of the profession,

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there has been none, I think, of which the majority of our members have been more sceptical than about hard rubber; nor is there one which has realized more fully all that was hoped for it by its first supporters; and it is interesting to note the gradual dispersion of the clouds and doubts which at first enveloped it.

We will glance briefly at the history of this substance, and explain some of the properties possessed by it, which render it peculiarly adapted to our purpose, with the method of manipulating and the process of vulcanizing.

Caoutchouc or india-rubber is, as you are aware, the concrete juice of the Syringe tree of Cayenne and other parts of South America. For the first knowledge in Europe of the source of this substance, we are indebted to some French academicians, who were sent out for the purpose of astronomical observation in 1735. They discovered that it was the white milky juice of certain plants found abundantly in Para, in the Brazils, and since found in Asia. Of late years considerable quantities have been brought from Java, Penang, Singapore, and Assam. The trees grow so abundantly in some places that hundreds of miles are covered with them. Caoutchouc oozes out as a vegetable milk from incisions made in the tree. It is collected chiefly in wet weather, when it flows most abundantly. The method of inspissating and indurating it are kept

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secret. It appears, however, that the juice thickens and hardens gradually on exposure to the air, and that as soon as it becomes solid it displays an extraordinary degree of flexibility and elasticity. Hence it is supposed that the natives make moulds of clay, or some substance that can be easily broken, and cover them repeatedly with layers of the juice, allowing each layer to dry before the next is applied. When the proper thickness is obtained, the mould with its elastic covering is held over the smoke of a wood fire. The mould is then broken out, and the dried bottle forms the india-rubber of commerce.

The specific gravity of caoutchouc is about 0·925. It is made hard, but never brittle by cold. When boiled in water or alcohol, it swells and softens, and in that state is readily acted on by those substances which dissolve it; but it is insoluble both in water and in alcohol. It is soluble in washed ether, which however, rejects the sooty and albuminous impurities, so that by precipitating a clear ethereal solution by means of alcohol, the caoutchouc may be obtained in its milky form. It also dissolves in sulphuret of carbon, in naphtha assisted by heat, in the rectified oils of coal and wood, and in the oils of turpentine, lavendar, and sassafras. Nitric acid renders it yellow, and assisted by heat decomposes it. It is charred on its surface by

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sulphuric acid. It melts at 248°, and according to Farraday its composition is carbon 87.2, Hydrogen 12.8.

The combination of caoutchouc with sulphur produces what we call vulcanite or vulcanized india-rubber. The process of conversion consists in submitting india-rubber to the action of bi-sulphuret of carbon, mixed with chloride of sulphur. The caoutchouc cannot however be penètrated by this process to any depth, and therefore it is inapplicable when the mass to be acted on is thick. The process of vulcanization originally invented by Mr. Handcock is usually adopted. When caoutchouc is immersed in a bath of fused sulphur and heated to various temperatures, it absorbs the sulphur, assumes a carbonized appearance, and lastly acquires the consistency of horn. In the course of those changes it attains the state of vulcanization which fits it for use. The same vulcanized condition can however be produced by kneading the india-rubber with sulphur, and then exposing it to a temperature of 190°, or by dissolving it in any of the solvents already named charged with sulphur.

Mr. Handcock secured a patent in 1843 for what he termed, "A process of hardening a compound of india-rubber by steam-heat, and moulding it into various forms, for use in the arts, sciences, or manufactures." But it is to

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a Mr. Goodyear, jun., who obtained a patent for some improvements on the preceding in 1855, that we are indebted for the idea of applying it to dental purposes. He, with the assistance of Mr. Bevan, made a number of experiments with the view of bringing it into practical use as a substitute for the bases employed in mechanical dentistry, and more especially to supplant the use of bone. Failing to perfect his idea, he wisely placed the materials and the results of his experiments in the hands of several experienced dentists, men who would take an interest in the subject, and by their practical knowledge assist in carrying out his views. In this he was not disappointed, as the rapid improvements made by these men testify. In the "American Journal of Dental Science," of January, 1856, we find the following, headed "What next?" "We see it stated in the papers that Mr. Charles Goodyear, now in Paris, has recently obtained letters patent for constructing a basis for artificial teeth, consisting of a hard compound of caoutchouc and gutta-percha, mixed with sulphur and then subjected to heat, forming a vulcanized compound of the two first articles. We presume the caoutchouc and gutta-percha are first bleached white, and afterwards made of a gum colour by mixing them with colouring matter. Whether the compound will resist for a length of time the action of the secretions of the mouth, we are not in-

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formed. If it will do this, it may form a valuable acquisition to the resources of the dental art, provided artificial teeth can be lightly and securely mounted on this base, as they can be on a metallic plate. These are questions we have not seen answered." Time has, I trust, developed the answer to the satisfaction of the writer of this.

Notices of a similar character, and of an equally superficial nature, appeared in other periodicals from time to time; but in the July number of the same journal, we have something like a detailed account of the material itself, with the method of manipulating and vulcanizing it. Since that period much has been written, and numerous have been the claimants for the honour of having first introduced it to the profession in a practical form, from all of which it would appear that many were engaged with more or less success in experimenting upon it at the same time; but amongst them, there is one whose claim stands pre-eminent; and if we are indebted to Handcock for the materials, and to Goodyear for its application to dentistry, we are still more so to Putnam, who, by a series of laborious experiments, not simply on the material, but on the various methods of working and vulcanizing it, thoroughly elaborated its usefulness, simplified the entire process, and introduced it into general practice, in almost as perfect a state

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as we now have it; for though there may be some slight differences in the modes of manipulating, in the form of flask or machine for vulcanizing, the process is essentially the same as that which he placed originally in our hands; for which the profession must ever remain his debtor. The rubber also, though now certainly improved in colour, is, in quality, no better than that first introduced by Putnam. The results of his experiments you will find in a paper read before the Odontological Society, and now published in the second volume of its Transactions, a paper containing much valuable information on the subject of vulcanite. Since the reading of that paper we have been rapidly progressing in the knowledge and use of it, and we now understand its real value, and feel better able to judge to what cases it is most adapted. Year after year gives us some new, if not improved, flask or vulcanizer, and various combinations of the rubber are being continually introduced, each one said to possess some good and peculiar quality, to which its predecessor can lay no claim; but all proving the extent to which vulcanite is used, and the interest taken in it. The exact proportions of rubber, percha, sulphur, and colouring matter, used to produce those different compounds, we are of course ignorant of, such being secrets only known to the parties who manufacture them.

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Having briefly glanced at its history, its introduction to the dental laboratory and its composition, we will now endeavour to consider its adaptability to our use, and how far it is suitable for the variety of cases which come under our hands, and I believe we shall find that it possesses many of the properties or characteristics essential in any material of which we would construct a base for our artificial teeth.

One of the first of these requirements is that it should possess as nearly as possible the characteristics of the natural structure to be replaced. A second, that it should have sufficient strength to hold the artificial teeth securely in their places, and withstand for a reasonable time the wear and tear of mastication. A third, that it should, if possible, be capable of resisting the destructive influences arising from the natural and morbid secretions of the mouth. A fourth, though not an essential, is a great desideratum, where it can be produced,—that it should resemble in appearance the gum which it is to represent.

To these may be added the absence of certain qualities, the presence of which would render any material at least less valuable; such as an unpleasant taste, galvanic action, which, if peculiar to any substance, must to a greater or less degree, detract from its universal applicability.

We will now consider how far vulcanite meets these requirements. In reference to the first,

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there is no material, with the exception of bone, which so closely resembles nature as this hard rubber. Like the alveolus, it combines lightness with strength; it can be made in imitation of the gum surface (which can be replaced to any extent), is perfectly smooth and pleasant to the tongue, being capable of receiving the highest polish; and like bone, it readily adapts itself to, and has a certain congeniality with the mouth, not possessed by a metallic or mineral base. The second of these requirements is met by the fact that the teeth are so thoroughly imbedded in the rubber, which when vulcanized is hard and firm, that, especially in continuous cases, it can stand tolerably rough usage, and all the wear and tear incidental to mastication, with little likelihood of an accident. The third mentioned is that it should be capable of resisting the destructive influences of the secretions of the mouth. This it seems capable of doing in a surprising degree, and, in fact, as far as the oral secretions are concerned, I think the vulcanite base may be pronounced indestructible. It may be worn as long as the gum retains its form, and, as a consequence, the piece its fit. In this particular only vulcanite claims superiority over bone; but this we must allow is a very essential point, for there is no loosening of screws or shaking of teeth, as a consequence of decay. The fourth requirement I said was a desideratum, but not

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an essential property in a material intended for a dental base; viz., a capability of receiving and retaining a gum colour. In this point vulcanite is to a certain extent deficient, for though time and money have, I believe, been largely expended in making experiments to gain this object, hitherto they have not met with the success we could have desired. The Messrs. Ash have indeed produced something approximating to the required colour. Messrs. Falkner, Smale, Lemale, and others, have been very successful in producing a neutral-tinted description of which the entire body of the piece may be made; and if it cannot be said to be a gum colour, it is certainly a vast improvement on the ordinary kinds. All of these are improved by being placed in spirits of wine, and exposed to the rays of the sun. These productions, so far successful, lead us to hope that the objections to vulcanite on account of its colour may soon be entirely removed. I alluded to the absence of an unpleasant taste as being a desideratum. If vulcanite has any taste, it soon passes away on being worn; but I do not think there is any perceptible taste when the rubber is properly vulcanized, and the piece thoroughly polished. Being a non-metallic, non-conducting substance, the rubber is quite free from galvanic action.

I have not named the moderate price at which vulcanized pieces can be made, or the readiness

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with which they may be worked, as essential requisites, being of opinion that such considerations should ever hold a secondary place in our estimates of work. Our aim should ever be to produce the best, without reference to the price or labour required; but while we know this is the course every honourable practitioner will, and does follow, we cannot but feel that when two dentures can be produced to fit and look equally well, and to fulfil all the purposes of mastication and articulation in an equally satisfactory manner, the preference may be given to the one which can be produced with the smallest expenditure of time, labour, or money, even should it not display the same ingenuity, skill, or beauty of finish as the other. Hard rubber has now taken a high place in our dental laboratory, a position due to its enduring qualities, and its general applicability, as well as to the simplicity of its manipulation, and the cheapness of its production, qualities which, though we do not consider essential, we cannot ignore, and which the public, if not the dental profession, will ultimately reap the benefit of. Having now considered some of the properties of this hard rubber, we must, I think, admit that in a great number of cases it proves an admirable substitute for the lost structures, and a reliable base for artificial teeth.

It might be well to take notice here of one

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of the greatest objections frequently urged against the use of vulcanite. I allude to the injurious effects it is said to produce upon the mucous membrane of the mouth of some patients, and even to affect their constitutions generally. It has been alleged that small ulcers, sores, and other symptoms of salivation, both local and general, have been exhibited after the use of rubber cases, resulting, it is said, from the bi-sulphurate of mercury or vermilion, used as a colouring agent in the manufacture. In confirmation of this, it has been stated by some that the globules of mercury may be seen by the naked eye oozing from some of the rubbers supplied for our use. So far as I have been able to inquire into the matter, I have not been able to detect free mercury in any of the numerous rubbers which have come under my observation. I have also treated and subjected these rubbers to extreme pressure, with gold and copper foil between the layers, without being able to *ex*-press any signs of mercury, or the slightest stain of it on the foil. I can usually fire it in conjunction with gold, and I do not remember having ever seen the gold affected by it. We know the bi-sulphurate of mercury to be, what is termed, an insoluble powder, unaffected by nitric or muriatic acid, though it may be dissolved in a combination of both; and I see no evidence to show that it can be acted upon by the secretions of the

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mouth, more especially when retained in combination with the hardened rubber compound. Even if it did so, I am not disposed to think that the small quantity which the surface of a rubber piece would yield, could affect the mucous membrane or constitution to the extent which, it has been stated, these cases have done. I must conclude, therefore, that the effects produced are due to other causes than to the presence of mercury in the rubber, to some peculiar idiosyncrasy in the constitution which would reject any other than a gold base in contact with the gums, or to some general derangement of the system at the time of inserting the piece and quite independent of it. Such cases may, I think, be fairly classed with others of a similar character, which we have heard of in connection with the use of amalgam plugs, cases of which we hear, but happily never see, and which may be frequently traced to other sources than those assigned to them. It is almost superfluous in a Society such as this to enter into a detailed account of the various modes of manipulating the rubber, as I am sure all of us are at this time conversant with its use; but the brief description I shall now give, I offer with a view rather to elicit information than to impart it, believing that the daily practical experience of the members present may suggest improvements, the knowledge of which may be serviceable to us all.

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To illustrate the method of working and vulcanizing, we will take the case of an entire set, where absorption of the alveolus has taken place, requiring replacement of both teeth and gums. We will then describe some cases which simply require teeth fitted to the natural gum, covering the unabsorbed alveolus, or the still remaining roots. To proceed then with the set. Having procured the plaster model, and if possible the bite as a guide, take the selected teeth, bending the pins round and from each other, at the same time flattening the ends with the pliers. Then take a sheet of gutta-percha or wax prepared for the purpose (I prefer the latter), place it on the model and trim with knife or scissors to the required size. This will form a plate, on which the teeth are fixed in their position by the aid of wax and a spirit-lamp. When secured, the whole is built up with wax, smoothed, and moulded to as near the ultimate size of the piece as possible. The lower being advanced to the same stage and articulated with the upper by means of the bite, they may now be fitted in the mouth, their effect seen, and any necessary alterations made in the position of the teeth or their closure with one another. Some take the bite with them at this stage, moving and adjusting the piece as required; but I have found this an uncertain and troublesome proceeding, and prefer making a duplicate in hard wax, which

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can be cut and trimmed with the utmost facility. It is an excellent plan, also, to keep a set of swivels inserted in rough wooden plugs. These can be readily pushed into the wax pieces to carry the springs, which will be found most useful in adjusting and securing a correct bite—an essential thing, particularly in vulcanite cases, when the teeth cannot be moved a little out or in after the piece has been fired. The pieces being moulded and properly articulated together, proceed to prepare them for the reception of the rubber. To do so, take duplicates from the models. These must be shallow, with the lower parts left rough. Having fixed the modelled pieces upon them, take the lower, or No. 1 portion of the vulcanizing flask, fill it with soft plaster, place the model with the duplicate piece on it in the centre, sloping the plaster from the edge of the saucer towards the necks of the teeth. When hardened, the surface is made quite smooth, and coated with soft soap or grease, to ensure its separating readily from the second, or No. 2 portion of the flask, which is now placed in position and filled with liquid plaster. Care must be taken to shake it well down, that any confined air may escape. The lower, or No. 3 portion of the flask, is now put on, and the whole screwed together by means of the stirrup, or No. 4 portion. After remaining about a quarter of an hour to set, the whole is gradually heated,

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either by means of boiling water, in an oven, or in a pan attached to some of the vulcanizers. When heated sufficiently to soften, but not to melt the wax, it is removed and the flask divided, when the teeth will be found in the upper and the wax in the lower. The latter is then carefully removed, the moulds and teeth being thoroughly cleansed from it. Sometimes it is found necessary to remove the teeth for this purpose, but this is not always the case. They may also be cleaned by pouring hot water into the mould. You now proceed to pack, if steam heat is to be employed; if the dry, then the moulds must be baked until all moisture is evaporated from them.

The rubber is supplied to us in a plastic state, and in sheets of various thickness, averaging about the sixteenth of an inch. These we prepare by cutting them into small pieces, from one quarter to half an inch in length, by one quarter inch wide, then placing them on a dish prepared for the purpose and heated with hot water, still further to soften the rubber. Proceed to pack while the mould is still warm, by placing the pieces side by side and one upon the other, at the same time welding them together, carefully excluding all moisture or dirt from between the pieces. Proceed thus until the entire vacuum left by the wax is filled up, being careful rather to over than under fill it. When finished, the divided parts of the flask

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are put together again, a piece of linen being placed between the rubber and the model, the stirrup put on and the whole screwed down, or home, not suddenly, but gradually, occasionally heating the whole in order to soften the rubber. The flask may be repeatedly divided and all superfluous rubber removed, the linen being taken out previous to the final closing. It is not necessary that it should be quite home before being put in the vulcanizer, as the elasticity of the stirrup will drive it close as it becomes softened by the increased heat. The upper and lower being now advanced to the same stage, are both put in the vulcanizer, where they have to remain usually about two hours, the length of time depending on the amount of heat supplied and the description of rubber employed. The average heat required is about 300° Fahrenheit. It takes generally about fifteen or twenty minutes to get the vulcanite up to this heat. When sufficiently fired, the flask is taken out and plunged into cold water. It is then divided, and the piece taken out. In doing this great care is necessary, as there is some danger of breaking the teeth or of loosening them in their sockets, if the plaster is too warm, or the rubber not sufficiently set. Now proceed to fill and finish it up, as you would a bone piece. When intended for springs, the swivels may be placed in the modelled wax, and so bedded like

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the teeth in the rubber; but I prefer putting them in when the piece is nearly finished, taking care to grind the teeth away previously, in order to allow a free passage for the pins. They may be fastened by roughing and heating them, or in the ordinary way, with silk and cement. It may be found necessary in exceptional cases to fine-fit these pieces to the original model; but as a rule this should always be avoided. When the upper and lower are again articulated together, the set may be pronounced finished.

We will now turn our attention to a case in which the teeth are fitted either to the natural gum or to the roots, the alveolus being in its normal condition. The teeth are simply fitted to the gum as ordinary flat teeth would be fitted for a plate, the modelling wax taking the place of the gold. The teeth being fitted and secured in their proper position, are removed to the duplicate model on which they are fixed. In such cases, it is advisable to scrape the model slightly where the necks of the teeth come in contact with the gum, so that they may really seem to spring from it when placed in the mouth. Being firmly secured in position, the piece, as in the former case, is placed in No. 1 portion of the flask, previously filled with soft plaster, which is sloped upwards to the side of the teeth, not to their necks as in the case before described, but towards and over their cutting edge, then smoothed,

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and the remaining portion of the flask fitted up in the ordinary way. When separated, the teeth will of course be found in the lower portion of the flask, being held in their places by the overlapping plaster, which serves, at the same time, to keep them in close contact with the gum to which they were fitted. (This is not required when the gum is to be replaced.) It is in this particular that the process differs from that before mentioned. In cases where any teeth are left standing, they must be cut down as short as possible on the duplicate model previous to its being imbedded in the plaster, which must also be brought well up and round them to prevent their being fractured, when the flask is separated previous to packing, or when it is re-screwed afterwards. These rubber pieces, though well adapted for suction, cannot always be sustained by that means in their places; accordingly, we are often compelled to resort to the ordinary bands and clasps for that purpose. In many cases the bands may be made of the rubber and continuous with the piece; but if we find it necessary to insert gold in flat or wire, they may be applied after the piece is finished; but a better plan is to imbed them in the rubber. To do this the bands must be fitted to the teeth, and to the modelled piece; and one or more pins, similar to those inserted in the teeth, being soldered on to secure them firmly, the clasps of wire require

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only to be hooked and imbedded in a stout part of the piece. When placed in the flasks, the free ends must be kept well open, so that the plaster may lay hold of and retain them in their position during the packing, &c. Much nicety may be displayed in the application of these bands and clasps, and as there is no danger of their becoming loosened by decay, they may be made very light and elastic. Regulating plates, for which the rubber is well adapted, are made exactly in the same way. The clasps are inserted before or after vulcanizing, as may be most convenient. Being neither so hard as gold nor so fragile as bone, rubber is well fitted for such cases.

From the description given, you will see that the whole process of working in vulcanite is extremely simple; nevertheless, a well-matured judgment, which years of experience can alone give, is required, especially in placing the teeth in position to look natural, and to be perfect in their articulation. It must be remembered these pieces cannot be altered like those of bone or gold, and a mistake in the arrangement of the teeth must be fatal to their success. The instruments used in the process of vulcanizing are few and simple. A piece of round wire slightly bent, and flattened or bulbous at the point; another of a spear-shape to work between the teeth. These, with a spirit-lamp, form all the tools required for modelling and packing. I may

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here allude to a machine for the latter purpose, invented and patented by the late Mr. Dewar, of Aberdeen, and described by him in a paper read before the Odontological Society, April 2nd, 1860. The advantages claimed for it are, that it packs more quickly and effectually than can be done by the ordinary method; that the necessity of dividing the flask is removed, and so the teeth are held in the exact position in relation to the gum to which they were modelled or fitted; also that the diaphragm of rubber frequently found between the divided portions of the flask is removed, which alters the position of the teeth to the extent of its thickness. Although a very ingenious invention, I am doubtful whether it will ever be found practically useful. The ordinary method is so simple that it really leaves little to be desired, and with a certain amount of care and judgment, all the advantages claimed for this machine may be ensured by the other way. The act of packing may take a little more time; but this is counterbalanced by the time required to prepare and keep the machine in order. The flask I alluded to in describing the process of packing, and which is the one in general use, is called the Putnam flask, it having been invented by Mr. Putnam. It is very simple, and answers well all the required purposes. Some slight modifications, and it may be improvements, have been made upon it, but

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its general characteristics are retained in all others. Mr. Bennett has indeed made an addition to it, and one which seems likely to be very useful in some cases. It consists of the introduction of what he terms a gauge-plate between the second and the third portions of the flask. By it the thickness of the piece is regulated, and the rugæ of the natural plate reproduced on the external surface of the artificial one. A very ingenious self-packing flask has been invented by Mr. Palrick. In addition to these improvements in the body of the flask, springs in various forms have been added to the stirrup with the intention of compressing the rubber as it begins to soften, and to ensure the parts of the flask being driven quite home. If the instruments mentioned have to a certain extent retained their original simplicity, the vulcanizer itself has been metamorphosed a hundred times, assuming every variety of shape and form, to suit the fancy of the inventor or the requirements of the profession. The one first used by Putnam is described as being of enormous size and complicated in structure. The steam-chamber was the size of a sixteen-gallon cask, and the boiler contained 150 gallons of water, which was still insufficient for one vulcanizing, the supply being kept up by means of a hand force-pump against a pressure of 70 or 80 lb. to the square inch. This ponderous machine, after many experiments, was reduced

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to one about twelve inches in diameter and forty in length; but still consisting of two chambers, one for the water, the other for the steam and work to be vulcanized. This was the one first introduced into this country by Mr. Putnam, and for which, with the patent right to use the rubber, &c., he found it necessary to demand a high price, higher indeed than the majority of dentists cared to give. Others were by this induced to set to work, and an improved vulcanizer was brought out by the Messrs. Ash, called by the name of the inventor and patentee, Mr. Child. This one is now much used. It consists of one chamber, which has to be filled with subsaturated steam, generated from a wineglassful of water placed in it, or from plaster soaked in water. It is affirmed that the use of subsaturated steam greatly lessens the danger of explosion, while the rubber is equally well hardened by it. Mr. Putnam now dispensed with one of the chambers of his machine, reduced it in size, and by a neat application of the Bunsen burner, made it at once the neatest and most cleanly and compact of all now in use. Child's machine has also been reduced in size and otherwise improved. Besides these there are various ones of all sizes and forms, both for steam heat and dry heat; and there are not wanting advocates for each one, who uphold the superiority of their own particular machines or methods of

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treating the rubber. Experience alone can decide among so many contending claims. Opinion is now universally expressed in favour of steam, and an abundance of it. I never knew of a piece having been injured by too much steam, though many have been destroyed for want of it. The verdict of Putnam in its favour is being gradually confirmed, and the value of his experiments and soundness of his judgment proved.

In concluding, I must remind you that although vulcanite undoubtedly possesses many of the qualities of gold and bone, yet it is by no means adapted to all cases, and must therefore be used with judgment and care. It is applicable to all cases in which bone may be made use of, but can never with safety be made even half as thin as gold, and is therefore unsuitable for the majority of cases. Experience must teach us to what cases it is best adapted, and under what circumstances it is safe to make use of it. One thing is clear, that it has been used injudiciously in hundreds of cases which were totally unsuited for it, and has in consequence been productive of injury both to the reputation and to the pocket of the practitioner. Therefore, I repeat, it must be used cautiously and with discrimination.

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Mr. J. T. Browne Mason read a Paper on—

The Reparation of Loss of the Superior Maxillary Region, the result of Lupus.

Mr. President and Gentlemen,—I have great pleasure in bringing before your notice a case wherein I was enabled with a frame of vulcanite to give great relief by replacing the loss occasioned by a formidable attack of lupus, and I think, from the amount of the loss the patient had sustained, that the case was one beyond the ordinary average of those *susceptible of improvement* after the dire ravages of this disease, and therefore it may encourage others, whose lot it may be to encounter similar cases, to endeavour to relieve even a patient like this, who could neither masticate nor speak intelligibly, and for whom there seemed but poor chance of any improvement.

The patient had been some time previously an inmate of the Devon and Exeter Hospital, under treatment for lupus, and was in due time discharged; but he presented himself again at this institution last Christmas, to ascertain if anything could be done to ameliorate his condition, as although now quite free from disease, he could not obtain work, not only on account of his appearance, but also because his speech was perfectly unintelligible. On this occasion

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H. Roper, Esq., one of the Hospital surgeons, pronounced the case as hopeless for surgical relief, and asked me to see him. I have had a photograph taken that you may better be able to form an opinion as to the state he was in. You will perceive from the lower margin of the orbits to the lower jaw there was nothing perfect, the nose being represented by a small hole, and the mouth merely a larger hole rather beneath it. Features there were none. The lower jaw was uninjured. On examining the interior, I found the losses extended through the whole superior maxillary region as far as the floor of the orbits. Of the two superior maxillary bones themselves there was nothing left except the malar processes and the orbital plates, whilst the nasal, palate, inferior turbinated bones, and a large portion of the ethmoid, were included in the wreck; so there was nothing for the intended frame to rest on, except the malar processes and orbital plates of the superior maxillary bones, and the remains of the ethmoid.

I have brought the model of the gap, for it cannot be called a mouth, with a frame similar to the one I employed. I did not attempt to replace the soft palate, which of course was gone, as I had no power of using anything that would not require frequently to be renewed; and as the patient lived at a considerable distance from Exeter, and was in very humble circumstances, this could

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not be managed; yet after all I found my trouble amply repaid, not only by his improved power of eating, but by his being able so far to speak that a stranger could perfectly understand him, whereas he had been previously quite unintelligible to those with whom he had constantly associated.

Mastication was hardly as perfect as I had at first hoped for, since the great depth extending from the palate to the upper part of the vulcanite frame prevented his getting the piece into his mouth, until I had removed the molar teeth I had just provided. The remnant of the upper lip had a deep cicatrix across it, which reduced the orifice of the mouth to a small round hole, which is stretched to the utmost to take in the piece corresponding to the one I have brought, and which for purposes of cleanliness is removed twice every day.

To render his appearance less repulsive, Mr. Packham, instrument-maker, of Exeter, made a false nose of flesh-coloured india rubber, a spring from which passing under the hair, over his head, was finally secured by an elastic band round his neck, a false moustache being added to make the junction between the nose and lip less conspicuous.

I may state that, from the contraction of the surrounding parts, the model and frame do not entirely represent a loss equal to that the patient

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had sustained; for instance, I was forced to make him under-hung, for the pressure on the lip, had I brought out the upper teeth over the under ones, would most likely have reopened the cicatrix.

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ANNUAL GENERAL MEETING.

January 14, 1867.

W. A. N. CATTLIN, Esq., President, in the Chair.

The following Gentlemen were duly elected Members of the Society:—

Mr. Henry Bell Longhurst, L.D.S., 20, Southampton Street, Bloomsbury.

Mr. Richard F. H. King, Appleton Gate, Newark. (Non-resident.)

The following Gentleman was proposed for the Membership of the Society:—

Senor E. Antonio L. Copat, Madrid. (Non-resident.)

The following Gentlemen were elected by ballot as Officers and Council for the ensuing year:—

President.—G. A. Ibbetson, Esq.

Vice-Presidents.—Resident: James Parkinson, Esq.; H. J. Barrett, Esq.; R. Hepburn, Esq. Non-resident: R. H. Moore, Esq. (Dublin); E. Parkinson, Esq. (Brighton); C. Bromley, Esq. (Southampton).

Treasurer.—Arnold Rogers, Esq.

Librarian.—J. B. Fletcher, Esq.

Honorary Secretaries.—Ordinary: J. Drew, Esq.; C. J. Fox, Esq. For Foreign Correspondence: C. Rogers, Esq.

Council.—Resident: R. T. Hulme, Esq.; S. Cartwright, Esq.; J. Saunders, Esq.; W. A. Harrison, Esq.; J. Tomes, Esq.; A. Coleman, Esq.; A. J. Woodhouse, Esq.; G. Gregson, Esq.; C. Vasey, Esq. Non-resident:—S. L. Rymer, Esq. (Croydon); T. R. M. English, Esq. (Birmingham); J. King, Esq. (York); N. King, Esq. (Exeter); C. D. Roberts, Esq. (Ramsgate); R. Ransom, Esq. (St. Leonards).

Mr. Tomes introduced to the notice of the Society an improvement in the construction of the spring mallet, by Mr. Brownlie, one of the students of the Dental Hospital of London. The original instrument

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had a sort of double crutch, which passed across the palm of the hand, allowing the fingers and thumb to act upon the fore part of the instrument. The double crutch was a fixture. Mr. Brownlie had recently made an instrument with a single crutch, which, rotating freely on the axis of the instrument, allowed a very free movement of the latter during the progress of an operation. This power of ready adaptation was a decided improvement.

Mr. FLETCHER exhibited a very curious and rare case of exostosis, showing a speculum of cementum starting out from the fang of a lower bicuspid. (See fig.)

Mr. C. J. FOX exhibited and explained some improvements he had suggested in Mr. Owen's operating-chair, which, with the addition of a moveable back, made to slide, and separate from the frame, upon which the seat moves up and down. The seat can be placed lower and raised higher than in the ordinary chair, and the back can be shifted up and down to suit the length of the patient's back. The head-piece is so shaped that by the mere act of raising or lowering the back the patient's head can be thrown backwards or forwards as desired.

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GENERAL MONTHLY MEETING.

Monday, February 4, 1867.

G. A. IBBETSON, Esq., President, in the Chair.

The following Gentleman was proposed as a Member of the Society:—

Mr. James Smith Turner, M.R.C.S., L.D.S., 30, Margaret Street, Cavendish Square.

The following Donation was made to the Society:—

Mr. Bridgeman, of Norwich.—A model showing the effects of hereditary syphilis on the teeth. Also a model of a case of gemination of the lower incisors.

Mr. Hepburn exhibited the model of the mouth of a patient who, several years previously, had received a kick from a horse, which caused a compound fracture of the lower maxilla, and subsequent loss of the anterior portion of the bone. The apparatus constructed to remedy the deficiency was also shown.

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The following paper was then read by Mr. JAMES BATE:—

On the Treatment of Decayed Teeth with Carbolic Acid, &c.

MR. PRESIDENT AND GENTLEMEN,—

The preservation of the teeth is acknowledged by every one to be of the greatest importance, and the dentist is bound to do his utmost for that object, and, above all, to preserve them in their entirety; for there is not the slightest doubt but that a tooth with its nerve in a state of health is in a much better condition, and will last a much longer time, than when that organ is destroyed. I have seen teeth that have had their nerves destroyed, remain healthy for a certain length of time, but after a little while alveolar abscess has broken out, and they have often become such a source of trouble and annoyance to the patients that they have been only too glad to have them extracted. This has occurred not only in my own practice, but in that of men of reputation: this I assert will, as a rule, be the case of almost all teeth so treated; they may last good for a year or two, but I contend that sooner or later they will become diseased; but still a tooth with an alveolar abscess is much better than an artificial one.

I am not *now* going to argue which is the best

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manner to destroy the nerve, knowing that it has already been ably handled, and with more justice than I could give it; but the subject is far from being exhausted. I cannot help remarking *en passant* that too much stress is laid upon the *extraction* of the dead nerve: the Americans are great sticklers for *this*. Now I am of opinion, sir, that it is *not* of much moment whether it is removed or not, for there are cases in which it is *impossible* to remove it; and what is the consequence? Let the reply of almost every dentist be the answer. "The great obstacle is, that it (the nerve) is *liable* to discolour the tooth; but if it happens to be a molar it is of *no consequence*, but should it be a front tooth it is a great misfortune."

I think the advice given by some to fill the fangs with cotton steeped in creosote is a mistaken mode of treatment: if they (the fangs) are to be filled at all, *gold* leaf ought to be the material; for there is no doubt, as it has been remarked, that the decomposing animal matter would soon saturate the wool and aggravate the complaint for which it was put in to remedy.

But to my subject. What I wish to bring before you is, the best means of preserving the pulp in a healthy condition. Various remedies have been brought forward, and each has had its advocate. Many teeth have been saved by the constant application of camp. spt.; but this

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is tedious, for it requires the spt. to be *incessantly* applied. This takes a considerable time, and many patients would rather lose the tooth than have so much trouble with it; and after all the trouble, it is doubtful as to success.

Tannin and camp. spt. I think far superior to camp. spt. *per se:* my manner of using it, is to take a saturated solution of camp. spt., and mix with it sufficient tannin to form a paste, clean well out the cavity, and then apply some of the paste directly on the exposed nerve, seal up with cotton and sanderach, allowing it to remain a week or more; at the end of which time fill permanently, placing a cap of ivory, or whatever is preferred, to prevent pressure on the nerve. I am, of course, supposing all to have gone on well, which I am sorry to say is not always the case. I have tried morphia, creosote, chloroform, *cum multis aliis*; but neither can be depended upon with any degree of certainty. A great secret of success is, to free the pulp from all surrounding decayed and diseased bone, and by opening it well up and giving it *free play*, if I may be allowed the term. I have found this alone, in many instances, relieve the most severe toothache.

Many teeth that I have treated in the above manner, I have had the opportunity of seeing, and have found them, after several years, all that could be desired; but to accomplish this it requires much patience and perseverance—patience

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on the part of the *patient* as well as the dentist. Sometimes it requires several months to accomplish the desired end, again only a few days may suffice, and again after every exertion has been made, failure is *frequently* the result. I would here state that the temperament of the patient ought to be taken into consideration. Should he be of a highly nervous and excitable disposition, I think we cannot confidently look for a successful issue, as a rule; but if he be of an even temperament, and in strong robust health, I think we may count on a fair average of success.

Before, however, proceeding further, I will give the different treatments followed by various authors.

Keoker states that he always avoided wounding the pulp, and where this has been unavoidable, he used the actual cautery. He did not favour the use of acids and styptics; after having prepared the tooth, he overlaid the nerve with a cap of thin sheet lead.

Mr. Bell advises the constant use of a moderate stimulus, as alcohol, camp. spt., and a solution of nitrate of silver, "till considerable pressure no longer occasions pain."

Mr. T. Rogers, in an excellent paper "On Capping the exposed Nerve," Transactions of Odontological Society, volume i., states that he employed arsenic, nitrate of silver, and chloride

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of antimony. He remarks, "For the successful performance of this operation, I conceive it necessary that the patient should be in good health, and not an inflammatory subject." These teeth are of the same class that I have treated.

Mr. Tomes recommends camp. spt., or a solution of mastic and spirit to be daily applied on cotton. He says it "will, if persevered in, produce the desired effect in hundreds of cases." Another method he recommends, and which has been more satisfactory in his hands, and requires to be removed less frequently, and consequently less expenditure of time, is tannin, mixed with gutta-percha, reduced to a gelatinous consistence with chloroform.

Mr. W. H. Waite, in a paper in the September number of the "British Journal of Dental Science," 1865; article, "Deep-seated Caries," recommends for sensitive dentine, "Creta precip., soda bicarb., aq. ammon., ol. creosotum, and if the pulp be much inflamed, apply for a day or two equal parts of ol. creosotum, and the acetate of morphia, at the same time recommending an aperient to be taken.

Several members of the profession are in the habit of using chloride of zinc, and speak of it in the highest terms.

Dr. E. Neumann, in a paper in the "Archives of Dentistry," volume i., page 367, translated from Langenbeck's "Archiv. für Klinishche Chirurgie,"

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vi. 1, states that he has used chlorate of potash with great success in teeth where the nerve has been laid bare. He illustrates a case that occurred with one of his own teeth: he says, "In order to obtain a thoroughly penetrating action, I put, during a violent attack of pain, some little crystals of salt into the very roomy cavity of the tooth, and repeated this during several hours without interruption, as often as the crystals had become quite dissolved by the fluids of the mouth. The favourable result was almost instantaneous; after some minutes not only did the paroxysms cease, but in the course of the application I soon perceived a relief from that annoying sensation in the tooth which had previously not even left me during the intermission of the pain." He also states that several of his colleagues had tried it with success. He recommends it to be used in a state of solution, "Chlorate of potash ʒij, water ʒv., as a wash, so as to avoid the danger which might ensue from careless handling of the crystallized salt, which, as is well known, belongs to the explosive compounds." He again observes, "Chlorate of potash has an almost unlimited activity in cases where there is inflammation of a pulp which has been completely laid bare by caries. Its action is uncertain where the irritation of the pulp is maintained by smaller carious cavities, which either do not communicate at all, or only by very limited openings, with the proper

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cavity of the tooth. Its employment is quite useless in periostitis of the root or alveolar process and their results." I have made this quotation, hoping that some of the members of our profession in this country have tried, and will give us their experience of this remedy.

I will now proceed with the remainder of my paper, viz., the treatment of painful teeth with carbolic acid. But before I do so, I will just remark that I have been in the habit of using cobalt with *great* success; the manner of so doing I gave in the "Dental Journal" for August, 1865.

Carbolic acid is a remedy I have been trying for the last twelve months. It is not new to the members of the profession, having been ably brought before this society last June by Mr. Woodhouse. Before stating my manner of using it, I may as well mention that as yet I have not had one failure, but I am in daily expectation of it; for I am not one of those who believe it to be an infallible remedy: a friend of mine who has used it in many cases has not met with the same uniform success. We have both used it in the same manner, and the only reasons I can give for the difference in the results are, first, that my patients may have been more amenable to treatment; and secondly, in placing the preparation in the tooth, it has been pressed too tightly down on to the nerve.

The cases I give are all those that I can see at any time, therefore of more value than

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those of which we are not able to obtain further information. If I cannot rely upon seeing my patient again, I never make a note.

Case 1. A young gentleman, aged about fifteen, first upper molar, right side, decayed on anterior approximal side, aching much, nerve bleeds at the slightest touch: well cleansed out the cavity, and freely excavated around the nerve, so as to give it *free play*, applied a small dossil of cotton impregnated with carbolic acid, allowed it to remain about twelve minutes, pain gradually subsided, plugged the tooth with amalgam: this was in July. Again saw the lad in December, and filled another tooth for him; the one that I had treated with the acid had not given him pain since, and was as useful as any he had in his head.

Case 2. Mrs. P—— called on me respecting a first bicuspid in the lower jaw, left side; had been painful for some time; on removing the decay, exposed the nerve, which bled, and also pained much; after freely opening it up, applied the acid in the same manner as the preceding case, allowed it to remain for about ten minutes, and then filled with amalgam, placing a piece of bibulous paper over the nerve. My patient remarked that what I applied had "quite a soothing effect." I have seen her since, and she told me that the tooth had not troubled her from the time she first called on me. This patient

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came with the determination of having the nerve destroyed, as did also the other.

Case 3. Young lady called respecting first under molar, right side, decayed on the masticating surface, was exceedingly tender, and had been aching for some time. As in the previous cases, removed all the decay, freely laying bare the nerve, applied carbolic acid on a dossil of cotton, allowing it to remain about eight or ten minutes, and then filled, overlaying the nerve with a cap of ivory. Have seen the aunt of the young lady several times since, and have always been informed that the tooth was comfortable. As I have before remarked, I always take great care to expose the nerve thoroughly.

Case 4. A young lady, a governess, second under molar, right side, decayed on the crown; had been aching all night, and also some little time before, treated it in the same manner as the preceding cases, but with this difference, instead of capping the nerve with any other material, allowed the cotton with the acid to remain in the tooth, and then fill over it with amalgam.

Case 5 is the last I shall give, feeling that those I have already illustrated are quite sufficient to advocate a more extended trial than has already been given to this invaluable remedy.

This is the case of a servant who called with the express determination of having the tooth extracted. After a great deal of persuasion I

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prevailed on her to allow me to try and keep the tooth in her head. It had been aching for several days. I well cleaned out the cavity and freed the nerve so as to give it full scope, and then applied the acid; the pain gradually diminished. Allowed the acid to remain about eight minutes, removed it and then applied a fresh quantity; filled over this, and when she left the pain had quite subsided. Since then she has been perfectly free from pain.

Now, as I have just remarked, the cases I have given are quite sufficient to warrant a fair and impartial trial of this most invaluable remedy. The acid I have employed has been in an undiluted form. In some of the cases I have treated, one application has been sufficient; in others I have been obliged to apply the remedy two or three times, but all at one sitting. I have generally applied the acid and then gone to other teeth that required attention, or else seen another patient, and when I have thought sufficient time had been allowed, I have returned to the tooth under treatment.

I have not tried it as recommended by Mr. Woodhouse for sluggish ulcers, or in the case of pivoting as mentioned by Mr. Owen, but with regard to the latter gentleman's remarks, I am inclined to doubt whether the acid had anything to do with the result he obtained; for in the first place I do not think it possible to inject so *small* a portion with effect into such a minute canal, and

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in the second I have seen many cases of teeth that have been pivoted under similar circumstances long before carbolic acid was ever heard of, and with the like results as he experienced.

Of course if the nerve canal had been enlarged by decay, as is frequently the case, that would *slightly* alter the circumstances; but even then the quantity he used would be *so small* that not *one third* of the acid (a drop was used) could *possibly* be injected, for the greater portion would adhere to the tube of the syringe. I merely make these remarks in hopes of eliciting the opinions of others; should I be wrong in my ideas I shall only be too glad to be corrected. It is only by the experience of others that we can arrive at a right mode of treatment in any case.

I have also experienced the same results as mentioned by Mr. Woodhouse—viz., a tooth that has been most painful in excavating the decay when the nerve is *not* exposed, has been entirely free from pain after the application of carbolic acid. In all the cases that I have treated I have well washed out the cavity with tepid water thrown in with a syringe *prior* to applying the acid.

I can fully understand that the injection of the acid and water into an alveolar abscess is of great utility; for here the quantity employed is more likely to be thrown in, and the part injected is of larger dimensions than the nerve canal of a tooth.

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I have always plugged the tooth permanently *directly after* using the acid, and in all I have employed an amalgam filling, and as I mentioned in the first part of my paper I have yet to see the first failure.

I have not had the opportunity of removing a single plug; but should I do so I will, if wished, at once report the state in which I find the cavities, but I have no doubt in my own mind that I shall find them in such a condition that they would be able to receive a gold plug.

I do not hesitate to say that had I not been in possession of this most excellent and invaluable remedy, I should either have had to extract the teeth, or else destroy the nerves; and, as I have already remarked, I feel doubtful of the latter operation, for I have invariably found alveolar abscess break out after a year or two, but generally in a much shorter time. I am not speaking of my own operations alone, but of those who speak and write strongly on the subject.

It has been remarked "that sensitive teeth may be filled perfectly well with gold in spite of pain at the time of preparing the cavity, and that no further inconvenience is felt." True, but how many patients will submit to the operation, which at times is intolerable? and I think if we can use anything to diminish that sensitiveness, we ought. Certainly we can obtund that pain with a few rapid cuts of the excavator, but even here the

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pain is also very acute; but I think an escharotic is more successful; at all events it is much more agreeable to the patient, and I think we are bound in all we undertake to study our patients' comforts.

Whilst writing this paper, a patient called to have a tooth, or rather a stump, extracted, second upper molar, left side. It had been broken in the attempt to remove it. It was causing her great agony. On examination I found it had been fractured well down; I advised her not to have it out, feeling sure she would not bear the operation.

I applied carbolic acid on a dossil of cotton, (it was bleeding at the time, the endeavour to extract it not having been long performed), the pain gradually subsided, the patient remarking that "it felt quite soothing." I merely mention this case to show the effect of the acid on a tooth that was in a great state of inflammation, brought on by three weeks of intense toothache, and increased by the attempt to extract it.

I fear that I have trespassed too long on your time, and that my remarks have been very wearisome. Would that it had been brought forward by abler hands; but having found such benefit in the use of carbolic acid, I could not resist the temptation of adding my experience with regard to this invaluable remedy.

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GENERAL MONTHLY MEETING.

Monday, March 4, 1867.

G. A. IBBETSON, Esq., President, in the Chair.

The following Gentleman was duly elected a Member of the Society:—

Senor E. Antonio L. Coopat, D.D.S., 10, Plazza Principe Alfonso, Madrid. (Non-Resident.)

The following Gentlemen were proposed for the Membership of the Society:—

Mr. John Ellis Mortimer.
Mr. William James Shiels.
Mr. Frederick Wright.
Mr. Robert Bell, L.D.S.
Mr. William Penny Bartlett, L.D.S.
Mr. Henry Harding, L.D.S.
Mr. John Dearden Bush, M.R.C.S.

The following Donations were made to the Society by:—

Mr. Fletcher. Vols. 1 and 2 of "L'Art Dentaire."
Mr. Winterbottom. The four first volumes of the "Dental Review."

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Mr. Ramsay read the following Paper—

On Congenital Cleft Palate.

Mr. President and Gentlemen,—When I had the honour and pleasure two years ago of reading a paper before this Society on the subject we have met again this evening to discuss, the subject was then, as you are aware, a comparatively novel one, inasmuch as it was a description of a method of supplying an instrument of suitable flexibility and firmness as a substitute for metallic plates and surgical operations in cases of Congenital Cleft Palate.

It is unnecessary for me on this occasion to travel over ground with which we are all familiar; therefore I will only recall the main objections to, or the shortcomings of, the two methods of treatment hitherto more generally practised.

In the first case, the introduction of a rigid metallic plate to supply the want of a flesh-like and muscular organ must necessarily be comparatively unsuitable, however perfect as a piece of workmanship. Even although it were made to fill up with accuracy the parts which Nature failed to supply, the pain which the patient would experience from the chafing of the muscles against any such hard substance would render its removal

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imperative. At any rate this has been the experience of all patients who have come under my notice to whom a metallic instrument had been supplied. In regard to the surgical operation I will here only remark it is of a most painful character, and is not always followed by satisfactory results.

If, therefore, we can take advantage of the discoveries of this most ingenious age, and adapt an instrument to each case that will completely fill up a defect which a mysterious freak of nature caused to exist, and do this with a substance so similar in its consistency to the natural flesh that it may be worn with comfort by the patient, then, I think, we may congratulate ourselves on having at length discovered a successful method of mechanically treating these very difficult cases.

In coming to the practical and scientific questions before us, it need hardly be said that the all-important material for us to work upon, or with, is a preparation of india-rubber which is so chemically treated that the elasticity and firmness required are admirably produced, while its toughness or enduring qualities are not impaired. More than this need not be said in this place on these points. On my first appearing in my present position before the members of this society, I introduced a patient who was suffering from Congenital Cleft Palate, and to whom I had applied one of the instruments upon Dr. Kingsley's principle for

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remedying the defect. As this kind of treatment was, as I have reminded you, a novelty in this country at that time, my sole object in bringing the patient before you was that you might have the opportunity of judging of his power of articulation at the time when the instrument was first applied; this I did that you might have the means for forming an opinion from practical observation of his progress in articulation as time wore on; time being, as you must allow, necessarily required to test the utility of any treatment for remedying the imperfect articulation which always accompanies cleft palates. In this object I was, however, to a great extent defeated; for instead of the time being allowed to expire between this meeting and the description I had promised of my practical observation, I was pressed, and I must say, gentlemen, very much against my will, to prepare a paper for reading before you at that early stage of my experience. The satisfactory demonstration which I had anticipated was only partially realized; but short as was the time which had intervened between the evening when the patient was before you, I had the gratification of hearing it said or implied by all who had been present on each occasion, that the boy's articulation had in that short time greatly improved. Now, however, two years having expired, I come before you under very different circumstances; the time has

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come, I am happy to say, when I think I may justly speak with the greatest confidence in regard to the instruments I have applied and the practice I pursue in applying them. From the uniform success without exception which has attended my operation, and from the marvellously beneficial results which have followed my treatment of several very distressing cases, I now come before you to expound as fully as I can the experience I have had, and on the ground of this success to advocate for the relief of the afflicted and the comfort of their relations and friends, the adoption of this in my opinion the best of all systems for treating these malformations. In justification of the spirit in which I have made use of these expressions I will here add, par parenthesis, if any of you gentlemen have a method more peculiarly your own for mechanically repairing cleft palates, or for remedying any other physical defects which flesh is heir to, and you can conscientiously speak with the same confidence which I possess with regard to this system, let me beg of you not to hide your light under a bushel, but in the liberal spirit of the age and the interests of humanity to bring it before this society that it may be thoroughly ventilated, understood, and practised; for it is by these means alone that any profession is nowadays elevated to a high position, and to do this will tend to rapidly raise our profession to that eleva-

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tion in the scientific world which we all believe it is gaining not only in this country but in every other civilized nation.

In my former paper I gave a detailed explanation of my *modus operandi* in constructing these instruments; and although my increased familiarity with these cases has enabled me to somewhat simplify the treatment of them, I cannot with any confidence recommend any one at the onset to do less, in point of detail, than I then endeavoured to convey. Besides, every man falls into a particular style of doing anything which is not rigidly or specifically defined for imitation, and it is by practice alone that a high order of skill can be obtained, no matter how plainly a theory may be given. Since I gave that description, I may, however, say my study has been not only to see how I could simplify the *modus operandi*, but also to make the instruments themselves more simple in construction; and I feel assured when the models I have prepared are handed round you will allow that nothing more simple or less liable to disarrangement could be constructed as a mechanical contrivance for remedying cleft palates. The main difficulties which have hitherto existed in the mechanical treatment of these cases have been the complication of parts, and their easy derangement, and when disarrangement happened the trouble and delay which often necessarily occurred in getting the damaged parts repaired.

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These instruments, however, to which I am now directing your attention, are not only simplicity itself, but they cannot by any possibility be disarranged while in use. Nay, when the construction of one of them has been perfected, they may be easily duplicated. So readily is this done that I have supplied five or six instruments to each of several of my patients who were going abroad, and in some cases I have taught them to make the instruments themselves from the model and mould which I supplied.

Another great drawback to all other mechanical contrivances which have come under my notice is the support given to them by fastenings to the teeth. However beautifully and accurately these may be adapted to the position of the teeth at the time—as these fastenings promote if, they do not cause, their decay—a new arrangement of fastenings will frequently be necessary; and if the patients should live to middle or old age, there would probably be no teeth left to which they could be attached, when the appliance would, as a matter of course, have to be abandoned. My instruments are, however, entirely self-supporting, and can be applied as well when there are no teeth as when these organs are perfect.

In some other appliances, too, which have come under my notice, the whole object of the operator appeared to me to have been to per-

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manently plug the passages to the posterior nares. Now it is as necessary to have these passages open for the perfect articulation of certain words as it is to have them closed at other times. In this respect I again confidently submit that my instruments are far superior; for from being grasped, so to express this action, by the muscles of the soft palate, the patient has the power of closing and opening these passages at will. It is surprising to find the strength which is in time acquired by the flexor and tensor muscles of the soft palate. In fact, the use of my instruments seems to put them through a course of gymnastics, if I may so term it, which tends to develop and strengthen them in an extraordinary manner. In proof of this I may here mention this strange physiological fact, viz.:— After one of these instruments has been worn by any one for some time, the muscles which were previously flaccid and inert will have acquired such a power of action that if he even were to give up the use of the instrument altogether, so great an improvement of the patient's original power of articulation would be the result, that the trouble which had been taken would have been amply repaid. Others seem to imagine that a simple flap closing the cleft of the soft palate would be all that was necessary. This, however, in my opinion, is a mistake, as there is no flap that can be applied which will not droop in a very short time. At

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any rate this has been my experience; and I have found that for this flap to be of any use at all it must be supported by springs or some other mechanical contrivance which gives a mechanical action to the instrument, whereas our object should be production of a natural action. In my instruments, I may say, reliance is altogether placed on a natural action; for they are held under such perfect control by the muscles of the soft palate that, as I have mentioned, these muscles gain strength when they have been accustomed to an instrument for some time. Thus, it seems to me, one of these instruments answers all the purposes of the soft palate as naturally as can possibly be attained by any mechanical contrivance. Besides, in all the cases which I treated, as I formerly did, on the flap principle, my patients were much troubled with their food getting on the top of the instrument, rendering its removal and cleansing after meals absolutely necessary. With the instruments at present under our notice, however, there is no inconvenience of this description, as all my patients, without exception, have found their deglutition much improved. So much so indeed is this the case, and especially when the clefts are of any size, that, if it were only for this comfort, they would be satisfied with the results. Another advantage that results in the continuous use of one of these instruments is the tendency they have to reduce

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the size of the cleft, while rigid appliances have naturally a tendency to enlarge them. In one case which I treated, the cleft contracted so much in eight months' use of the instrument that I had then no alternative but to remodel the velum; but that which I consider the great advantage is the early age at which these instruments may be applied. Hitherto, and no matter whether a surgical operation or a mechanical application was contemplated, it has been thought indispensable that the patient should have acquired the age of sixteen years at least, but these instruments I have applied at the early age of ten years. My first case of so juvenile an age occurred over two years ago; and although the young gentleman has since grown several inches taller, and proportionately increased in size in every way, he still continues to wear the identical instrument I then fitted, and this with so much comfort to himself that he now declares it has become an essential part of his existence.

When the young gentleman first came to me, it was with the greatest difficulty that he made himself at all understood; in point of fact I do not believe that any one excepting his parents, who judged as much by the muscles of his face as by his speech, could have made anything out of what he tried to say. His speech now, however, though peculiar as regards sound, is perfectly intelligible, and I have no doubt that by the time he

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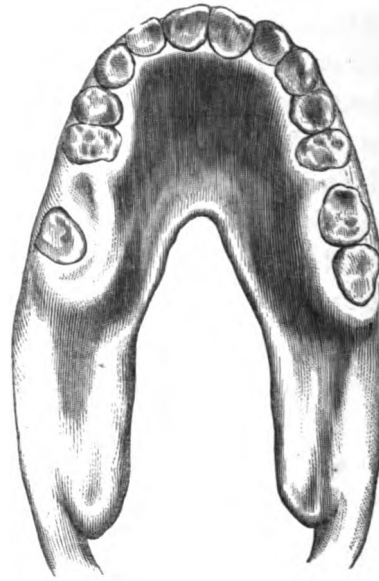
arrives at the age of sixteen he will have acquired an ordinarily perfect articulation. Another case which I have just treated is that of a young gentleman, eight years of age; but the instrument has been so recently fitted that I will only mention the fact. However, on the strength of

FIG. 1.



The mouth without the velum applied, showing the extreme width of cleft both at the anterior portion and across from point to point of bifurcated uvula.

this experience I may say I am quite prepared to undertake, with every confidence, even younger cases. Indeed, I have no hesitation in saying that even at the early age of five or six years these

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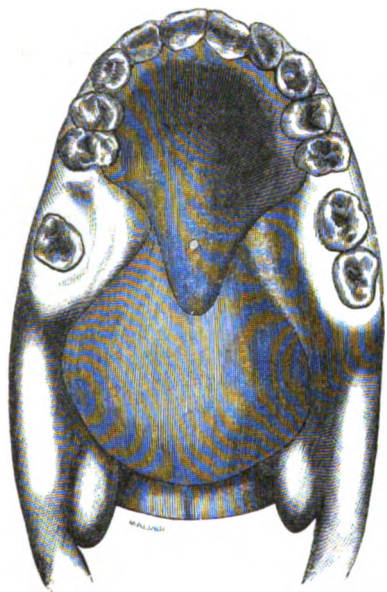
instruments may, with due care, be successfully applied, and subsequently worn with comfort and effect. I will now more pointedly advocate the treatment of these cases by mechanical means, as preferable to surgical operations. In the first place in many of these deformities the membrane

FIG. 2.



The case shown in Fig. 1 with the new instrument *in situ;* the hard rubber front piece supplying loss of hard palate, and the soft palate supplied by means of the elastic rubber artificial velum.

of the cleft is too thin, or the cleft itself too wide to admit of any reasonable attempt at a surgical operation. I have brought before you models of

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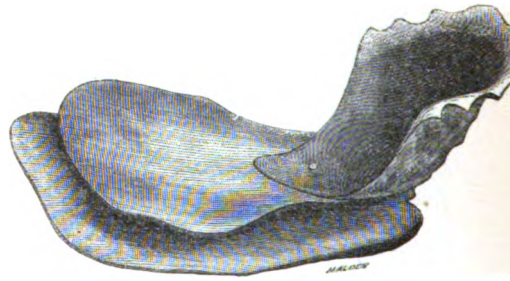
both of these cases. Here is one of a young lady, and, as will be seen, it is an enormous fissure, the soft palate being almost entirely absent, and the hard palate partially divided. (Figs. 1, 2, and 3.) This case was seen by the surgeon most eminent in the present day for treating these cases with the knife and needle, and he at once stated it would be impossible for him to attempt to operate. This patient is a young lady aged seventeen, and of a fair complexion, and sanguine temperament. The

FIG. 3.



The instrument out of the mouth.*

second case also relates to a young lady of about the same age, and similar complexion and temperament. Here, however, the surgical operation was attempted, but, as will be judged, it was necessarily a failure, as no union of the parts could be produced, through the deficiency of flesh and thinness of the membrane. It is of course very gratifying for me to be able to say that I have

* For further particulars as to construction see fig. 7.

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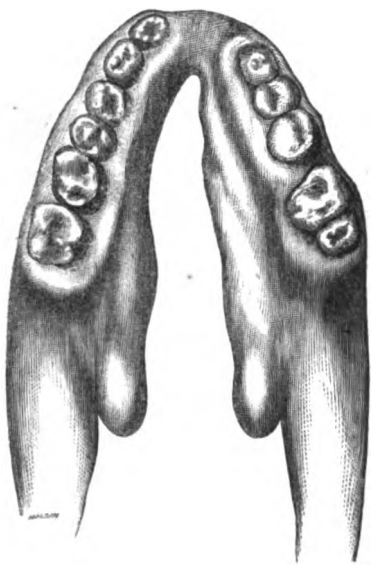
treated both of the cases mechanically with most satisfactory results. The next case which I have to present to your notice is that of a young gentleman, aged twenty, and who is also of fair complexion. Here the fissure extends not only through the soft and hard palates, but also through the superior maxillary bone, while it is accompanied with hare-lip, the latter having been operated upon in childhood (fig. 4). When the

FIG. 4.



Showing the cleft extending through the soft palate and the maxillary bone, including external alveolar plate.

patient was first presented to me, he had only one of his central incisors fully developed, and it had

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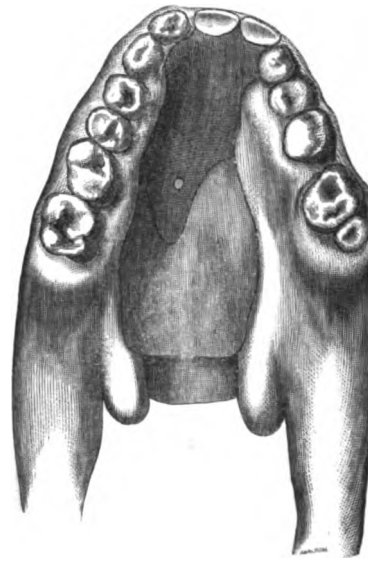
taken a transverse position in the cleft. It was with much difficulty that I induced my patient to consent to having this tooth extracted; but he at length yielded. When the wound healed, there was no other obstacle to proceeding with my

FIG. 5.



The instrument fitted in. The front piece with teeth attached rendering the hard palate symmetrical in form, the elastic velum supplying the deficiency in soft palate; the bifurcated uvula playing between the upper and lower flaps, thus assisting deglutition, and the upper flap at the same time closing the posterior opening of the nares.

process of modelling his palate, and I was speedily successful in bringing his mouth to the symmetrical form which is displayed in this model (fig. 5).

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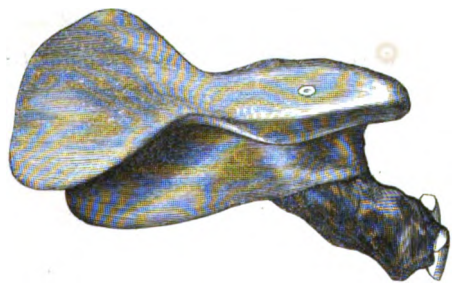
Subsequently, however, to the introduction of this instrument the other central incisor appeared; but as my patient had by this time every confidence in me, he submitted at once to its removal. We have not since been troubled with any more intrusions. This young gentleman's articulation before the introduction of the instrument I fitted to his mouth, was very imperfect, and on many occasions he was obliged to write what he wished to express before he could make himself understood. The great difficulty with him was, there

FIG. 6.



The instrument out of the mouth. The upper small end plugging up the gap in the floor of the anterior portion of the nares and serving as an overlap for the support of the velum in the cleft; the hard rubber suction front piece supplying the loss of teeth and substance in hard palate, while at the same time it keeps the instrument *in situ*, thereby avoiding the necessity of any attachment to the natural teeth.*

was no distinguishing difference between his B, C, D, E, and P; in fact, they were all pronounced E.

* For further particulars of this instrument see fig. 8.

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S was also an impossibility, as were H, K, Q, and R. But now, although he has had the instrument in use only fifteen months, he can pronounce every letter in the alphabet most distinctly, and his general conversation is equally intelligible. The sound of his voice, as you would conjecture, is still peculiar, but I have every confidence that this drawback will ultimately be very much lessened. The improvement in his mastication and deglutition has in every way been so satisfactory that, as it is with all my other patients, the instrument he wears has become an indispensable member of his existence (fig. 6). In this case, all that the surgical operator could have accomplished would have been the union of the soft palate, leaving the cleft in the hard palate to be closed by an obturator, supported by the teeth. Besides, I have yet to witness a case where congenital cleft palate, even in its most modified form, could be so surgically treated as to give that improvement in articulation which this patient has happily displayed. When I say I have this young gentleman present, and you have heard him display his present speaking capabilities, I feel assured you will not think I have been carried away by an excess of enthusiasm or egotistical feeling, but that you will attribute any little glowing expression of self-satisfaction that may have escaped me, to the genuine pleasure which all earnest men must feel when they have met with

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such uniform success in the practice of any speciality.* If you will permit me, I will now briefly describe three other cases with some of the indirect advantages which attended them. This model [model handed round] is one relating to a young gentleman of fair complexion, and eighteen years of age. This is fissure of the soft palate only. In this instance a surgical operation could have been performed with more than an ordinary chance of success, and an eminent surgeon proposed to operate; but nothing could induce the young gentleman to submit. His parents were most anxious that he should have whatever assistance surgical skill could give him, and they tried what persuasion would do for several years, as there was an appointment in a public office which could be obtained for him, if his defective speech could be remedied. Two years ago they were informed of my method of treatment, and after a short consultation, the youth was readily induced to place himself in my hands, when I soon fitted an instrument to his mouth. In his case I am pleased to say the improvement in his speech was so great and rapid that in six months he was able to accept the appointment.

The next case relates to a young lady of fair complexion and seventeen years of age. A surgical operation could here have been performed

* This gentleman has since been elected an officer in his Volunteer Rifle Corps and also in the local Volunteer Fire Brigade.

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even more favourably than in the last case, as it is simply a partial fissure of the soft palate; but, like the young gentleman, nothing could induce her to submit to the knife and needle. I closed the fissure in the manner you will observe in this model, which you will perceive differs materially from the others. Here you see there is no top flap. I found that from the fissure being so small the muscles ultimately took such a firm hold of the instrument, and held it by the neck under such complete control, that this usual flap could be altogether dispensed with. It is a little over two months since I finished this case, and the patient is gradually improving in articulation. In fact, there was a most decided advance, not only in the tone of the voice, but in the formation of words, immediately on its introduction; so much so that certain syllables which she could not previously articulate at all, were at once managed with ease.

I have chosen these five models from the number of cases I have treated, as they demonstrate nearly every character of congenital cleft palate that can be met with. There are many cases complicated with hare-lip, where there is a greater loss of the maxillary bone than in the one to which I have called your attention this evening. I have met with several of these more extreme cases; but, though looking more formidable, they are treated just as readily as the case before us;

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and my only reason for making this selection was that I was favoured with the opportunity of simultaneously producing the patient. This case, however, is quite sufficient to show that no depth or other difficulties attending congenital cleft palates can present themselves which cannot be treated mechanically; whereas it is only in extremely modified cases that the surgical operation can be attempted, and even then successful results are doubtful. Surgeons themselves even give the best evidence in favour of the mechanical over surgical treatment; for, with scarcely a single exception, they have abandoned the system, and this, in most instances, from a conscientious conviction that the results which have attended it do not warrant them in again operating. As direct evidence of this, I may say that nearly every case I have treated has been recommended me by a surgeon; and I am proud to add that every surgeon who has thus seen cases mechanically treated by me has most cordially acknowledged the superiority of my method to any surgical operation that could possibly be performed.

Before I close my paper I have a few general observations which I am desirous of making. These relate to the character of persons among whom I find congenital cleft palates and the questions which are often asked as to whether these cases are or are not hereditary.

As to the first, my experience is that they are

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equally distributed among the rich as well as the poor. If you desire of me a theory that would tangibly account for the occurrence of congenital cases of cleft palate, I candidly confess that I have never read, heard, or seen anything which I can accept as fair grounds on which to base a theory. The following observations are, however, remarkable, and I shall be glad to hear if they fully harmonize with the experience of gentlemen present. Every case which has come under my notice has been that of a patient who was of nervous temperament and fair complexion, and I have never seen a case where the complexion was dark and the temperament approached the lymphatic.

In regard to the second, my opinion is that they are not hereditary; for in no case which has been presented to me can I trace either on the father's or mother's side that any of their family were so afflicted; whereas I know a gentleman in the city of London whose case I treated, and which consisted in congenital cleft palate accompanied with hare-lip, and who has a fine healthy family, not a trace of their father's defect being visible. This has occurred, too, although his wife was constantly dreading that the child she was bearing might inherit its father's deformity. Another instance is that of a lady having congenital cleft palate, but no hare-lip, whose family of five children are without the slightest symptom of

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their mother's affliction. The only other case, or rather family of cases which I will mention, is a most extraordinary one. Three members of the family referred too are so afflicted. Their respective ages are 17, 30, and 35; the first and last are ladies, the other is a gentleman, who is married and is blessed with several fine children, not one of them having a trace of cleft palate. Having seen these and several other cases, and heard of many more similar instances, I have evidence enough, in my opinion, to warrant me in saying that a congenital cleft palate is *not* hereditary.

Having said this much on the subject of congenital cleft palates, I will now bring to your notice two very interesting cases which occurred from what I will here term accidental causes. These I have selected as they are unusual and extreme cases of their kind. The first is one where the loss of bone has been very great without being accompanied, it is singular to say, by any reduction of the soft palate. The second is a case of great loss of the soft palate only, while the adjacent bones have not in the slightest degree been affected. These models illustrate the manner in which these cases have been successfully treated. The object I have in presenting them for your examination is simply to show how great is the professional service which can be rendered by working out the mechanical

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principle we are considering, and adopting for this purpose this valuable material and agent, elastic rubber.

The following engravings show the two parts of the instrument detached. The soft velum being connected to the front hard rubber piece by means of the platina pin shown in the right-hand drawing; the elastic portion, which is the only thing perishable, can be readily duplicated by means of the metallic moulds brought before the notice of the Society in my paper read May, 1865.

Fig. 7.

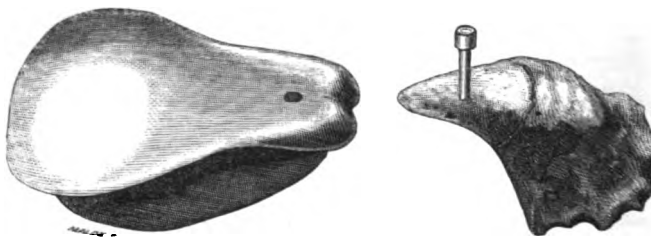
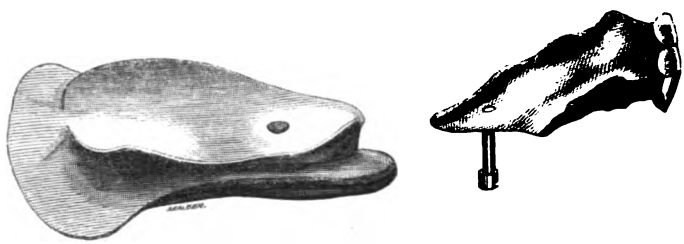


Fig. 8.



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GENERAL MONTHLY MEETING.

Monday, April 1, 1867.

G. A. IBBETSON, Esq., President, in the Chair.

The following Gentleman was duly elected a Member of the Society:—

James Smith Turner, M.R.C.S., L.D.S., 30, Margaret Street, Cavendish Square.

The following Gentlemen were proposed for the Membership of the Society:—

Mr. James Oakley Coles.
Mr. Edwin Frederick Lane, L.D.S.
Mr. Simeon Haslam.

The following Donations were made to the Society by—

Dr. Thos. W. Evans of Paris. "On the Discovery of Vulcanized Caoutchouc;" "Essais d'Hygiene et de Thérapeutique Militaire;" "La Commission Sanitaire des Etats Unis."

Mr. Underwood exhibited a lower molar very extensively exostosed.

Dr. Richardson brought before the Society the modifications and improvements which had been made in the ether-spray apparatus for dental purposes, since he first had the pleasure of introducing it to their notice. Before passing to that, he would say that, in respect to the production of local anæsthesia by the ether-spray—and he said it in that Society with supreme pleasure, because it was the first public body before which it was brought—the whole result, taking it *en masse*, had entirely surpassed his own most sanguine expectations. The process had been adopted in every part of the world, and had formed the subject of essay and comment by writers in nearly every language where science was taught. It had been used on some of the battle-fields of Mexico, and was specially referred to by Professor Neudorfer, who had taken part in those campaigns, as well as in the Austrian and Italian campaigns.

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Turning to the department of Dentistry, he observed that during the past year there had been four, or perhaps he might say five, useful modifications, none of them made by himself, and all deserving considerable credit.

The first to which he would refer was the modification in the original tube made by Mr. Owen. It consisted in having a second tube, giving a return current of air, so that the ether-spray was brought back again from the mouth, preventing, to a certain extent, the accumulation of ether. It was rather more applicable to the older than to the more modern ethers, of which he had yet to speak. The past ethers, having a higher boiling-point, accumulated in the mouth, and Mr. Owen's instrument was then of very great use.

The next modification he would point out consisted of some little sponges for absorbing the ether, invented by Mr. Kecwick, of Carlisle. He (Dr. Richardson) had used them on several occasions, and found them exceedingly useful, though sometimes, perhaps, a little in the way. These sponges were not so important, now that they had made an advance with regard to the ether, but still they were very acceptable.

Then again, a very ingenious modification by Mr. Welsh, of Brighton —a little plate fixed on the side of the spray-producing tube, preventing the ether coming in contact with the mouth. The plate was surrounded with lint before it was placed in the mouth.

And there was a little modification which had been suggested by a great many persons, but which really was originally brought out by Messrs. Krohne and Seseman. It consisted of a small pair of bellows, worked by the foot, so that the foot was placed on the bellows, and with a long tube the action could be kept up, and both hands were at liberty. He had in his own mind at first an idea of putting a pair of bellows between two boards, but other things diverted his attention from it, and Messrs. Krohne and Seseman brought out the instrument at their own instance. Mr. Kirby, of Bedford, recommended a similar contrivance. He (Dr. Richardson) had only used these foot-bellows lately, but was so pleased with its results, that he should be inclined to use it on all occasions. He had not generally been using the ether-spray and operating at the same time, and therefore had not felt the difficulty of working the hand-bellows. Still, it was so useful to have both hands at liberty, that he thought this a most important improvement, and for dental purposes it would answer every requirement.

In addition, Messrs. Krohne and Seseman had brought out an air-condenser. The jar could be charged before the patient was admitted into the room, and could be kept charged for a considerable time. The spray produced by it was exceedingly good, and was entirely at the command of the operator, who had also both hands at liberty.

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The last improvement to which he (Dr. Richardson) would direct attention, was the compound ether which he had recently introduced, made specially by Messrs. Robins & Camp, of 372, Oxford Street. As soon as the ether-spray became well known, various attempts were made to improve the fluid. When he first commenced to use ether, he found there was not such a thing as pure ether in the commerce of the United Kingdom. It was not to be obtained; and although the older men —Cavallo and Franklin—must have had a good ether, for they could produce with it cold down to zero, yet the manufacture of absolute ether, owing to the Pharmacopœia allowing a certain measure of alcohol, had become a delusion. He found that much of the so-called ether was a mixture of ether and a very indifferent form of alcohol (methylated), and not an absolute alcohol. This was a very bad fluid, boiling at 106°, or not lower than 110°—a very bad ether in every way. He first commenced by making an absolute ether having boiling-points from 94° to 96°, and all the researches on the ether-spray were made with that kind of ether. But in a little time news came from America that Dr. Bigelow had brought out a substance which he called "rhigolene," a nearly natural product of petroleum or paraffin. It existed in abundance in America, and was sold so cheaply that one could scarcely imagine there was any great pains taken in the preparation. A little later, another paraffin or petroleum, obtained probably from a different source, was bronght out, and took the name of "chimogene." Those were nearly pure hydro-carbons; and the "rhigolene" had a boiling-point of from 62° to 64°, while the "chimogene" has a boiling-point of from even 50° to 58° or 60°. Professor Neudorfer, travelling through the United States, collected some of these specimens, and was so good as to furnish him with them. Some specimens of "rhigolene" were also brought over from New York and sold in this city. On experimenting with these hydro-carbons, he found that from their very low boiling-point they were as objectionable as ether was from its high boiling-point. The ether was too slow in its action, while these were too rapid. The way in which ethers act turned upon the power which they have of abstracting so much heat from the body in a given time. Now, a body with a comparatively low boiling-point, say 94° or 96°, when playing upon a surface like the human body, would begin immediately to operate and produce a certain amount of cold sufficient to freeze. But when they got to the lower boiling ethers, those that boil at 70° or 80°, they contained so much latent heat that they were evaporated too quickly: consequently, the anæsthesia produced was very superficial, and the ether was to a very large extent lost. Anæsthesia could be produced by these low-boiling hydro-carbons, but a great deal more fluid was required; they must use ounces where with

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a fluid of a higher boiling-point they would use drachms. The effects of these American introductions were not so satisfactory as it was supposed they would be; for it was assumed that the lower the boiling-point the more useful the liquid would be. Another objection to them was that in hot weather they disappeared altogether. In fact, "chimogene" in this climate, for a considerable part of the year, would exist as a gas; it could not exist as a fluid at all.

However, these were fluids not to be despised. There was a certain rapidity of action about them bringing quick results which everybody was satisfied to see. The question was how to imbibe them, and he tried various plans. At first he tried admixtures of common paraffins, but to no great effect. At last it occurred to him that he had made, more than three years ago, while the ether-spray was revolving in his mind, some experiments as to what boiling-point was the best for producing rapid insensibility, and had determined theoretically that the boiling-point of 84° was the nearest. On making some experiments bearing upon the matter, he found that that was strictly correct, and that a mean boiling-point of 84° was the best that could be had for local anæsthesia by the ether-spray. The question was, how to produce a fluid exactly like that. After trying many plans, it occurred to him that he should succeed best in this way: by taking an ether that had a fixed boiling-point, whether 90°, 94°, or 96°, and then by taking another fluid, one of the hydro-carbons—not caring about the boiling-point, because no two specimens had the same—and mixing these fluids, to distil over at 84° exactly. That succeeded at once. It was an experiment that only had to be thought of to be successful. It turned out to be a very happy union. The two bodies kept well together, and so exactly did they combine that in some experiments every drop would equally evaporate. They had, therefore, a compound ether which he thought could not possibly be improved upon. There was some trouble in making it, and until paraffins were cheaper it would be somewhat expensive; but yet it was not so expensive as common ether, because so much less was required. The anæsthesia resulting from its application was of the most perfect kind, and was produced in five seconds. He had not seen it more than five seconds in a very large number of operations. If the skin was damp or the air was damp, it might make a difference of two or three seconds, but five was the average; and when once the insensibility had commenced, the rapidity with which it could be extended was most remarkable.

With regard to teeth, the results were equally satisfactory. The action was not quite so rapid as on the skin, but the whiteness was produced within fifteen strokes of the bellows; the insensibility was

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very deep, and could be extended with great rapidity. Further, the saliva did not interfere so much with this fluid as it did with the ether, and there was less accumulation; in fact, the fluid was so volatile that there was virtually no accumulation of it in the mouth. If we chose to run to refinements, it might be well to have a fluid with even a little lower boiling-point for the teeth than 84°—perhaps 80° or 82°. But taking practice as a whole, and considering what difficulties there would be in supplying just what was wanted for one special department of surgery, the special application of that kind of ether was almost precluded, and the Dental profession must remain satisfied with the new compound ether.

He (Dr. Richardson) had heard of no serious result from the use of the ether-spray. Not only had there never been a death from it out of from 200,000 to 300,000 applications, but nothing like a serious slough had been produced. In two cases, the subjects of Bright's disease, he had seen slight vesication, lasting two or three days; but as for deep slough, where even portions of bone came away, that had never followed the use of the spray; the reason being the rapidity of the action. The action was so rapid, the condensation of the tissue was so quick, that there was no disorganization produced in the vessels during the period of application.

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The following Paper was read by C. Spence Bate, F.R.S., F.L.S., Cor. M.Z.S., &c.:—

On the Dentition in the Mole (Talpa Europæa).

Mr. President and Gentlemen,—Among all the families of the Mammalia, we find none in which there is a greater variation in the dental arrangement than in that of the *Talpidæ*.

The number of the teeth is larger than in any of the order, except the marsupials, and only deficient by four in the set, from the full number of the mammalian type.

The development of the teeth in this family is so little known, that the greatest divergence of opinion, as to their homological distinction, exists among zoologists. Thus we find in Professor Owen's "Odontography," four different formulas given, being the result of as many distinct anatomists' observations, which may be expressed as follows:—

That of M. Fred. Cuvier, as—

$$\text{In. } \frac{3}{4},\ \text{c. } \frac{1}{0},\ \text{pm. } \frac{4}{4},\ \frac{3}{3} \times 2 = 44;$$

Professor Bell:—

$$\text{In. } \frac{3}{4},\ \text{c. } \frac{1}{1},\ \text{m. } \frac{7}{6} \times 2 = 44;$$

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Professor De Blainville:—

$$\text{In. } \frac{4}{4},\ \text{c. } \frac{1}{1},\ \text{pm. } \frac{3}{3},\ \text{m. } \frac{3}{3} \times 2 = 44;$$

Professor Owen:—

$$\text{In. } \frac{3}{3},\ \text{c. } \frac{1}{1},\ \text{pm. } \frac{4}{4},\ \text{m. } \frac{3}{3} \times 2 = 44;$$

while Professor Blasius gives, in his "Fauna der Wirbelthiere Deutschlands," a fifth—

$$\text{In. } \frac{3}{4},\ \text{c. } \frac{1}{1},\ \text{pm. } \frac{3}{2},\ \text{m. } \frac{4}{4} \times 2 = 44.$$

Thus we have five formulas expressive of as many separate opinions. It was therefore with some degree of satisfaction that I succeeded some time since in obtaining several specimens of young moles, as by the dissection of these I hoped to be able to clear up the several points of difficulty, and establish the homological relation of each separate tooth beyond dispute.

In the upper jaw of the adult mole we find on each side, most anteriorly situated, three small teeth (Plate II., fig. 1, in. 1, 2, 3), that by their broad, flat cutting edges and general form and appearance, are such as would be determined as the incisor teeth, and in the lower jaw, corresponding to them, are four (Plate II., fig. 2, in. 1, 2, 3, and c.) other teeth. In size these are some-

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what less than those of the upper jaw, since the four occupy the space of the three above; but three of them correspond in form and manner of implantation, whereas the fourth (Plate II., fig. 3, c.), although a not more important tooth in respect to size, differs from the others somewhat in shape and its position in the jaw. It is more pointed than either of the preceding, having the posterior margin sloping, being quite diagonal in relation to the tooth, and its external surface traversed by a strong protuberance in the form of a vertical ridge. In position it is implanted further inwards in the jaw, and consequently lies more obliquely outwards than either of the anterior teeth. These four have likewise been pronounced to be incisors by all anatomists except Professor Owen, who has stated the last (c.) to be a canine, because, in closing the mouth, it bites before the large tooth that he assumed to be a canine in the upper jaw. But this large cusped tooth (Plate II., fig. 1, c., and Plate V., fig. 1, c.), so much like a canine in carnivorous animals, has the remarkable peculiarity of being implanted in the jaw by two large equal-sized fangs or roots, a circumstance that is not known among mammals to exist in teeth situated in the mouth anteriorly to the premolars.

In the lower jaw there is a corresponding large cusped tooth (Plate II., fig. 2, 1 pm., and Plate V., fig. 2, 1 pm.), that Bell, Blainville, and Bla-

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sius consider to be a canine, and Cuvier and Owen state to be a premolar.

In form and general appearance, as well as the manner by which it is implanted in the jaw, it corresponds with the large canine-like tooth of the upper jaw, but is not quite as large and powerful; and as it impinges when the mouth is closed against the posterior surface of the corresponding tooth in the upper jaw, Professor Owen says that it is not a canine. Behind this large canine-like tooth in the upper jaw, are four double-fanged teeth (Plate II., fig. 1, pm. 1, 2, 3, 4, and Plate V., fig. 1, pm. 1, 2, 3, 4), that are formed upon the type of the canine, the anterior resembling it most nearly, and the last assimilate to it the least, in consequence of the development of the posterior lobe, which increases gradually on the posterior surface in each premolar tooth. The teeth gradually decrease in size from the first to the third, while the fourth or last premolar suddenly increases in dimensions to that of the first in height, but broader by the development of the posterior cusp.

In the lower jaw, posterior to the large double-fanged tooth (Plate II., fig. 2, pm. 1, and Plate V., fig. 2, pm. 1), that Professor Owen and F. Cuvier say is a premolar, and all other naturalists have pronounced to be a canine, are three doubled-fanged teeth (pm. 2, 3, 4), of which the anterior is the smallest, and the pos-

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terior the largest. Each of these is developed upon the type of the tooth immediately preceding it; but the last has the posterior extremity broader than the anterior, in this respect assimilating nearer to the character of the molar rather than that of the teeth anterior to it. Behind these several teeth, both in the upper and lower jaw, are the three large molar, or permanent teeth (Plate II., fig. 1, m. 1, 2, 3), that have not been anticipated by any deciduous ones. Those in the upper jaw are bicusped and trifanged; the cusps and the fangs corresponding in position, two being on the outer margin of the jaw, and one on the inner. The outer cusps are more elevated and more pointed than the inner, and have the outer surface convoluted, while the extremities and intermediate space between the cusps are thickened and produced into prominences, that take the place in the three teeth of more or less important secondary cusps. The inner cusp is less elevated than the outer ones, and stands, as it were, at a lower level. It is placed on the inner and anterior margin of the tooth, from which it slopes diagonally to the external and posterior angle of the tooth. This line is most direct in the third, or posterior molar tooth, and the least so in the first or anterior, where it takes a slight contour; so rounding and strengthening the general character of the tooth. They are so planted in the jaw, as to have the

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anterior margin square, or at right angles with the external line of the jaw; so, in consequence of the oblique direction of the posterior margin, a very considerable space separates the teeth on the inner side, while on the outer they are in close contact with each other. These large angular spaces between the molar teeth are occupied, when the mouth is closed, by the projection of the large anterior and external cusp of the lower molar teeth. The fangs of the teeth are situated at the limits of the three angles of the teeth, and consequently stand widely apart from each other. This appears to be increased from the extreme shortness of the implantation of the fangs in the jaw, which extend to a depth that is scarcely, if at all, greater than the height of the cusps above the jaw. This shortness of the fangs increases posteriorly, which is superinduced by a deep groove that lies above the teeth, which is occupied by the optic nerve and rudimentary organs of vision and the anterior mastoid muscle; the object of which muscle is to draw forward the lower jaw so as to enable the incisor teeth to bite in direct antagonism with each other. That the jaw has this direct forward movement there can be no doubt, for we find the articular socket furnished anteriorly with a bony process, that evidently is intended to preclude the possibility of the dislocation of the lower jaw; whereas the large development of the

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inferior angle is evidently intended for the attachment of muscle that shall force the jaw back again into its normal place of rest.

The molar teeth of the lower jaw (Plate II., fig. 2, m. 1, 2, 3) are five-cusped, two of which are on the outer surface, and three upon the inner; the two posterior of the inner side coinciding in line with the two upon the outer, from which last the margin of the tooth runs obliquely to the anterior cusp upon the inner margin; thus narrowing the tooth to a point that is directed anteriorly; whereas the two cusps at the posterior margin stand square, or at right angles, with the external and internal surface of the jaw, and in this aspect are reversed from those of the upper jaw, where the broadest part of the tooth is situated anteriorly, and the narrowest posteriorly. The second and third molar teeth are developed upon the same plan as the first; but the external cusps become more elevated, and in the second there is also a sixth, or rudimentary cusp, between the two posterior cusps upon the inner side.

In closing the mouth, the four small incisor-like teeth of the lower jaw bite within the three incisors of the upper. The large upper canine-like tooth of the lower jaw is separated by an interspace from the small teeth in front, into which space the large canine-like tooth of the upper jaw bites, both between and outside the teeth, and

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passing beyond them to an extent that the apex of the upper tooth comes, when shut, into a line with the lower margin of the inferior jaw; whereas the large cusped tooth of the lower jaw, when closed, reaches no farther than to the base of the crown of the tooth of the upper jaw; that is, the apex of the lower tooth rests in juxtaposition with the soft tissues of the anterior arch of the mouth.

The three next teeth of the lower jaw bite behind and somewhat within the three corresponding teeth of the upper. These several teeth in both jaws are small and short, and when the jaws are brought into close contact, the apex of the lower scarcely passes that of the upper in each of these teeth. The upper last premolar tooth bites immediately in front and outside of the molars of the lower jaw, the descending cusp biting into the space left by the last lower premolar and the oblique line of the anterior and outer wall of the first molar; consequently, the first molar of the lower jaw bites between the last premolar and the first molar of the upper jaw, the anterior external cusps of the former biting between the two upper teeth and the posterior outer, as well as corresponding inner cusp of the same tooth bites within and anteriorly to the posterior cusp of the upper, which consequently falls into the angular space left on the outside between the first and second molars, and that the

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anterior external cusp of the second lower molar drives its point into the angular space left on the inside between the first and second molars of the upper jaw. This mode of antagonism between the first molars in the two jaws is repeated in the second and third molars, the last of which in each jaw is reduced in size to compensate for the alternating bite of the several teeth. We consequently perceive that the small secondary cusps of the upper molar teeth are not available in biting, and consequently are only required to strengthen the tall, slender, and sharp-pointed cusps into which the surfaces of the teeth are divided.

Having made out the forms and position of the several teeth and the relation that they bear to each other, we have now to determine the problem of their homological relations to the teeth in the great order of Mammalia in general.

In the placental mammals the largest number of teeth are forty-eight, and consist of three molars, four premolars, one canine, and four incisors on each side of each jaw. In the European mole we find them all present, excepting one on each side of each jaw. Accordingly, the opinions of the several comparative anatomists are differently expressed. M. Fred. Cuvier leaves out an incisor from the upper jaw and the canine from the lower. Professor Bell leaves out an incisor from the upper jaw and a molar from the

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lower; or, since he classifies the premolars and molars under the name of molars, we may say that he omits a premolar from the lower jaw. Professor De Blainville omits a premolar from the series in each jaw; while Professor Owen leaves out an incisor from each jaw, and Professor Blasius, the most recent comparative anatomist who has written on the subject, omits an incisor from the upper and a premolar from the lower jaw. But he also differs from all the previous writers in classifying the last premolar in the range of each jaw with the molars; thus reducing the number of premolars to three in the range of the upper jaw, and two in that of the lower. In this arrangement Professor Blasius has evidently been guided by the shape and size of the several teeth in comparison with the other permanent teeth in the mouth, rather than by any relative connection which the teeth may hold to the deciduous or milk teeth, or their position in the jaws. Such a classification is liable to variation with the various existing wants of animals, and therefore must possess a very shifting character, a condition that must exclude it from scientific consideration. The only true classification of the teeth must be based upon their position in the jaws and the homological relation that they hold to one another; thus, there are only three molar teeth, because in placental mammals there are but three teeth in the range of each jaw that are

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developed without having been preceded in their usefulness by a deciduous or milk tooth. Therefore the large tooth (Plate II., fig. 2, pm. 4) that has been classified by Professor Blasius as a premolar, and which is preceded by a deciduous tooth, is a premolar. All the teeth in the upper jaw that exist between the molars and the tooth which stands in the suture that separates the maxillary from the premaxillary bones, are premolars. The canine is known by its implantation in the upper jaw immediately in contiguity with the suture that divides the premaxillary from the maxillary bones; and the incisors consist of those teeth implanted in the interior premaxillary bones anterior to the canine teeth, and perhaps had better be designated "premaxillary teeth," from their position in the mouth, than that of "incisors," from their common but not constant functional condition. In the lower jaw the premolars are determined by their position in relation to other teeth only, since the development of the entire ramus on one side is in a single piece, and therefore no suture defines the limits of each group of teeth. Thus the premolars are all those situated between the molars and canine, and the incisors are those anterior to the canine. Thus it will be seen that the great object that we have to determine is the homological position of the tooth that is absent in the mole from the perfect formula of the placental mammals.

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Upon giving our attention to the jaw of the mature animal, we find that so complete an ossification has taken place between the points of union of the several plates that make up the jaw, that it is impossible to determine the points at issue. We therefore have to direct our attention to the appearances of the bones and the teeth during their formation; so, by observing the position which the permanent teeth may relatively hold to the deciduous, we may be able to determine their homological relation to the teeth of other animals.

At the period when the young mole is three inches and three-quarters or four inches long (Plate I.), the deciduous teeth are so far developed that some of them are cutting their way through the gums, and all of them are in a very forward state. The two premaxillary bones are separated by a distinct suture from the maxillary, and by an extensive fissure from the palatal plates, which they approach only in the median line by long projecting bony processes, and at the internal and external processes of the canine alveolus.

In these bones are situated, on each side of the central suture, the four anterior deciduous teeth (Plate III., fig. 1).

The first of which (d. in. 1) is the most anterior, and approximates the median line or suture between the premaxillary bones. It consists of a long curved cylindrical stem, with a flattened

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crown produced laterally towards the median line; it is about one-twentieth of an inch in length, and 200th of an inch in diameter. This represents the central incisor, of which the permanent tooth is in progress of development, closely posterior to it, to the extent of about half the crown.

The second tooth (d. in. 2) consists of a curved cylindrical tube, like the first, with a flattened crown, but somewhat distended on each side, so as to be nearly half broader than the shaft. This represents the second incisor, of which the permanent tooth has the crown about half-developed closely posterior to it.

The third deciduous tooth (d. in. 3) differs in nothing from the two preceding, except in having the crown proportionately longer and less produced laterally.

The fourth tooth (d. c. 4) differs from the preceding in being much stouter, having the crown not flattened, but terminating in a blunt cone. The crown of the tooth, if the termination of the enamel coincides with the constriction of the tooth, is much longer than in the preceding pairs, and the remaining portion or shaft of the tooth enlarges slightly, and again as gradually decreases to the apex of the root. This tooth is implanted within the limits of the premaxillary bones, the suture separating them from the maxillary passing through the posterior portion of its alveolus; thus demonstrating that this deciduous tooth is

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the true homologue of that of the canine in the mammalian type. Anteriorly in the same great alveolus is in progress of development the large scalpriform crown of the first permanent double-fanged tooth, which therefore we can now positively assert to be the homologue of the permanent true canine, the peculiar implantation of which must therefore be ascribed as a variation from the normal feature of the tooth to meet the requirements of a large and powerful tooth being implanted in a jaw insufficiently deep to receive a root of corresponding length.*

The succeeding deciduous next teeth are situated in the maxillary bones. These are the deciduous premolars, and are vertically followed by the permanent premolar teeth.

The first, or most anterior (d. pm. 1), consists of a curved cylindrical tube, somewhat shorter and more slender than that of the incisors, supporting a subconical crown, that is slightly broader in diameter than the shaft. This is followed by a second (d. pm. 2) and a third (d. pm. 3), of almost similar form, but of somewhat larger size. These are replaced by the three anterior double-fanged permanent premolars that exist at this period, in a forward state of development, on the palatal side of each of the deciduous teeth re-

* The author has occasionally seen, more frequently in the lower than in the upper jaw, the canine tooth in the human mouth divided at the extremity into two fangs.

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spectively. Posteriorly to these is a deciduous tooth (d. pm. 4), consisting of two long slender roots supporting a broad flat double-cusped crown, the crown being antero-posteriorly flattened. The anterior cusp stands pointing upwards, the posterior being directed backwards. This tooth is replaced by the last or fourth premolar tooth of the permanent set, and to which it bears a very general resemblance, differing mostly in the roots of the tooth, being in the deciduous tooth proportionately less robust.

These deciduous teeth are followed posteriorly by the three true molars, of which the two anterior are, at this time, in a forward state of development, and the posterior visible in its progress.

Of the lower jaw the bones are materially developed; but the mental symphysis is very distinct. The anterior or central incisor tooth (d. in. 1) of the deciduous set is broad, as nearly so as that of the upper jaw. It consists of a curved cylindrical tube-like fang, with a flattened crown, closely posterior, and in the same alveolus is the permanent incisor, in a very forward state.

The second deciduous tooth (d. in. 2) is smaller than the first, and, though flattened in the crown, is less broad. Posteriorly and laterally the permanent representation of this tooth has the crown nearly developed.

The third deciduous tooth (d. in. 3) differs little

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from the second. The permanent representative of this tooth is closely situated posteriorly to it.

The fourth deciduous tooth (d. c.) has a more conical crown; the fang is slightly curved, but has the central portion somewhat distended. The general resemblance that this bears to the upper deciduous tooth, that we have determined to be a canine, suggests that it is also the homotype of that tooth in the lower jaw. Immediately within, but rather anteriorly than posteriorly, a small triangular ossification, the apex of the future permanent representative, and which, both from its own shape as well as from its relation to deciduous canine, must be taken as the homologue of the canine in the lower jaw of mammals generally. This and the two permanent teeth, at this stage of their development, are closely compressed together, whereas a considerable space separates them from the one anteriorly as well as from the next posteriorly (d. pm. 1), which, in the permanent series, is the large tusk-like tooth that by so many comparative anatomists has been taken for the homologue of the inferior canines, and is anticipated deciduously by a small straight anteriorly-directed tooth surmounted by a subconical crown.

The two succeeding deciduous teeth (d. pm. 2-3) are similarly shaped to the last, and are followed in the permanent series by two double-fanged teeth.

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The next (d. pm. 4), which is the last, or most posterior, of the deciduous teeth, differs in form from any of the preceding; the tooth is much larger, and the crown is developed on the type of that of the permanent tooth, but the root-implantation is by a single fang, except at the extremity, where it is developed into two small roots of unequal size. This tooth is followed in the permanent succession by the double-fanged fourth premolar; and this in succession, posteriorly, by the three permanent molars, of which the first is in an advanced stage and the two others rapidly progressing in their development. By actual observation, we are therefore enabled to support the correctness of Professor Owen's inductive analysis, and demonstrate the homological relation of the teeth to be—

$$\text{Inc.}\ \frac{3}{3},\ \text{c.}\ \frac{1}{1},\ \text{pm.}\ \frac{4}{4},\ \text{m.}\ \frac{3}{3} \times 2 = 44;$$

or, according to Professor Owen's formula, to be—

$$\text{Inc.}\ \frac{3-3}{3-3},\ \text{c.}\ \frac{1-1}{1-1},\ \text{pm.}\ \frac{4-4}{4-4},\ \text{m.}\ \frac{3-3}{3-3} = 44;$$

while those of the deciduous set are—

$$\text{D. inc.}\ \frac{3}{3},\ \text{d. c.}\ \frac{1}{1},\ \text{d. pm.}\ \frac{4}{4} \times 2 = 32.$$

In the examination of the deciduous teeth of the mole, the first peculiarity that must strike the

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observer is the very simple character of these teeth, more particularly as regards the deciduous premolars, and also the distance in the jaws which they relatively hold from each other, when compared with the permanent teeth.

At the period of our examination, the young mole has no fur developed on its skin, and the teeth have not pierced the gums; while the small extent of fang yet to be produced at the extremity shows how near protrusion through the gum the period has arrived. Yet we cannot but be struck with the feeble connection existing between the teeth and the alveolar walls, which rather appear to be undergoing absorption and waste, for the purpose of the reception of the permanent set, than to be closing in order to support the milk-teeth for any efficient purpose. These circumstances, together with the forward state of development of the permanent set, suggest the idea that the deciduous teeth are developed according to a law of growth, but are not required to fulfil any purpose in the economy of the young animal's life, for they can scarcely be developed in their places before the period of the eruption of the permanent set, and this is probably coeval with the period when the fur is placed upon the young creature's back and it is enabled to furrow the soil for itself. This also receives corroboration from the cornuous state of the gingival ridge in the anterior portion of the mouth, which is

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evidently induced for the purpose of permitting the animal to seize, without biting, the parent while sucking.

The large spaces of separation that exist between the deciduous teeth, together with their feeble attachment to the jaws, which appears to be far less than that which exists between them and the fleshy gums, must make them useless as organs of mastication; and the form of the teeth demonstrates their incapability for crushing the horny structures of insects. This is most intensely exhibited in the character of the deciduous premolars, when compared with that of their permanent successors.

It is the most usual condition in the mammalia, above the cetaceans and bruta, for the deciduous teeth that anticipate the permanent premolars to be developed into a more complex form, assuming more nearly the shape and condition of the true molars, than do those of the permanent set, this we see very distinctly exhibited in the human mouth; but I believe it to be a rule subservient to the more general law,—that whenever teeth are developed, and are not required for the fulfilment of any especial function, they have a tendency to return to the primitive form of the teeth of the mammalian type.

And such I take to be the character of the deciduous teeth of the genus *Talpa*.

The general appearance of a section of a tooth

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of the mole, when seen under a two-thirds object-glass, shows that though all are capped with enamel, the arrangement of that substance varies in thickness on individual teeth, and also in different parts of the same tooth.

In the incisor teeth of both the upper and lower jaws the enamel appears to cover the crown of the tooth tolerably even, the greatest deficiency being apparently at the cutting edge, which is most probably due to the wear of mastication. In the large double-fanged canine it is largely developed upon the anterior and outer, but reduced to a considerably less amount on the posterior and inner surfaces. In this tooth there is a very minute ridge or prominence on the anterior surface just at or above the limit of the gum, which, in the section, is again represented at the posterior surface of the tooth in the same relative position. This ridge probably circumscribes the tooth, and it is just beneath this protuberance that the enamel thins away into the cementum. This same arrangement in the development of the enamel exists in the four next succeeding teeth (the premolars), but in each of which the gingival ridge, both anteriorly and posteriorly, is increasingly developed in each succeeding tooth; and it culminates to so great an extent in the fourth premolar that the tooth assumes the proportions and extent, to a great degree, of a molar tooth, and is suggestive of the

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idea that all the maxillary teeth, inclusive of the canine, are but modifications of the same typical form of tooth. In the molar teeth the enamel appears to cover the crown more evenly, but still thins out to a considerable extent in the deeper hollows and cavities. These same remarks of the arrangement of the enamel apply generally to the teeth of the lower as well as of the upper jaw.

A closer inspection with a higher power (one-fifth) shows the enamel to consist of fine slightly-waved columns; the direction of the structure being from the surface of the dentine or base outwards and downwards, that is, towards the root of the tooth; but this only for a very short distance, of about one-eighth of the thickness of the enamel, from which point it makes a somewhat sudden bend in the opposite direction, and passes in the segment of a circle to the external surface of the enamel. In some places the curve, towards the outer extremity of the enamel columns, is much more sudden, and deflects towards the root of the tooth to a very considerable extent, a circumstance that must do much to preclude the wearing of the enamel in its contact with resisting substances. In this case, moreover, the direction of the columns, instead of downwards, is upwards, and forms part of the regular columnal arch. In an oblique section the columns are seen to be thicker and larger than they appear in a vertical section.

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In a horizontal section of a molar tooth of the lower jaw the columns of enamel are seen to be first perpendicular to the dentine, then to pass laterally to near the outer extremity, where it is again deflected in a reverse direction, and the walls of the several columns assuming a waving or tremulous aspect, which is more apparent in some positions than in others, which may in part be due to the more or less oblique direction in which the section may be made.

The dentine of a tooth coincides in form more nearly with the original unossified pulp than any other part of the tooth. And as we may assume that in their earlier stages of development all organs are more probably in their most normal or typical stage, we may consider that the structure of the dentine, as it is seen in the pointed apices of the teeth, such as the canine and molar cusps, to be the most typically perfect condition of the structure, and that all deviations from that form are the result of altered conditions, inducing a variation in the development, such as occur where the tooth divides to form roots for implantation in the jaw, or at the interstices between the high pointed cusps. Looking first at the most normal condition of the dentine, we find that the central tubuli that traverse the structure, pass in the molar in a very direct line to the apex of the cusp, the secondary waves being very slight, less so than in a similar position in the canine. On

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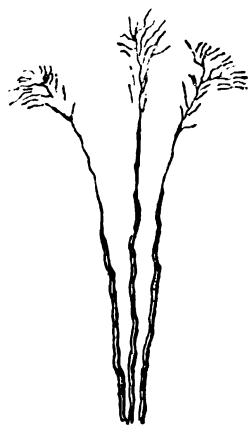
every side of the exact centre, the tubuli deflect towards the enamel, with which they appear to have a much closer connection than is seen to exist in the teeth of the placental mammals generally. The tubuli of the dentine, as they approach the peripheral surface, are furnished with a considerable number of minute branches. (Fig. A). These, as may well be seen in the apex of an upper canine,

Fig. A.



branch off on every side from the more central tubuli, the branches terminating at the apex in numerous small cavities, from which numerous minute branches are given off, and appear to pass into the enamel. On the side the dentinal tubuli break near the apex into numerous small tubuli. Occasionally one may be seen to give off branches through its whole extent, but they are generally at the extremity of the tubuli only, and increase

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in quantity towards the lower limits of the enamel. These branches (Fig. B) appear generally to termi-

Fig. B.

nate by anastomosis beneath the basement membrane (Raschkow), though frequently they may be seen to pass into the structure of the enamel itself. In some places, as in the premolar teeth, this may be seen to so great an extent, that in one instance we found it difficult to determine the limits of the two structures. Below the enamel, the tubuli are more irregular in their direction and more branching in their structure, and may be seen constantly to unite with each other throughout their entire length. Occasionally,

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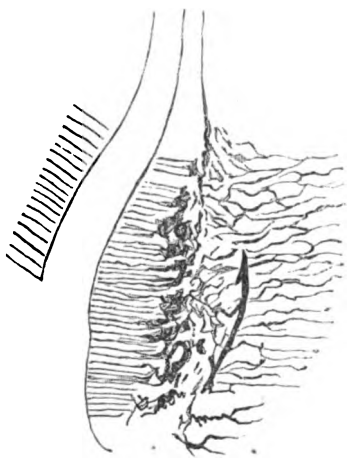
and this has always been observed in the posterior angle at the base of the enamel in the upper canine tooth, large irregularly-walled, loop-like canals may be seen; but at this point always the ramifications and intercommunications of the several systems of tubuli are most numerous and intricate. At this point also the cellular interspaces are occasionally very conspicuous, and seem to range in lines corresponding with the external surface of the tooth. Towards the ex-

Fig. C.



tremities of both the roots in the upper canine tooth—which in this animal are, in proportion to the great extent of the crown of the tooth, very short, though planted to as great a depth as the jaw will admit,—the tubuli inosculate at their ramose extremities with branches given off from

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a system of radiating cavities that hold an intermediate position between the dentine and the living tissue that envelops the outer walls of the tooth. These cavities, from their constant occurrence in this place, must be looked upon as a normal condition of the canine tooth. (Fig. C.)

The tissue which is recognized by the name of cementum, increases in thickness suddenly, to a very considerable extent. At about one-fourth the length of the root from the extremity, it undergoes considerable modification; on the outer side is a system of more or less fine tubuli that run direct to the external walls of the tooth, and on the inner side is a series of very irregular ramifications that open into numerous cavities that correspond with the contour of the external wall of the dentinal margin. This system of cavities, from its regularity and position, is an important secondary feeder to the dentine. The cavities, offering the facilities of reservoirs, contain the life-fluid of the structure, and hold an intermediate position between the dentine and the external circulating medium. The fine tubuli in the cementum that connect the system of cavities with the periodontal membrane, are straight and regular, and by their evenness and constancy rival the character of the true dentine in structure, and by their smallness are evidently

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intended, while they admit the serous portion of the blood, to keep out the red and coarser particles.

As common in dentinal structures, the great mass of the tooth is fed direct from the pulp, which is supplied by vessels that pass through the extremity of the roots; but it is also supplied by vessels of a large calibre that pass directly through the dentinal substance of the root to the pulp.

This occasionally occurs in the teeth of mammals generally; but from the frequency with which we have perceived it in the teeth of the mole, we are inclined to accept it as a normal condition, and that probably one or more such secondary connections of the pulp with the external vascular system exists in every tooth.

The circulation of the red particles of the blood extends to within a fifth of the length of the crown to the apex of the tooth, and after bifurcating to pass at the base into the two separate roots, in the anterior root of the canine, which, from its greater size and direction, must be looked upon as being the principal, and the posterior as being a branch of the system, the pulp expands near the centre of the root to so great an extent that there appears to be an effort in nature to produce a third implantation. This expansion or branching of the pulp is so very constant that it must be

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accepted as a normal feature of the upper canine, from which tooth, as being the leading feature of the dental system of the mole, we have made the principal source of our observations on the structure of the dentine.

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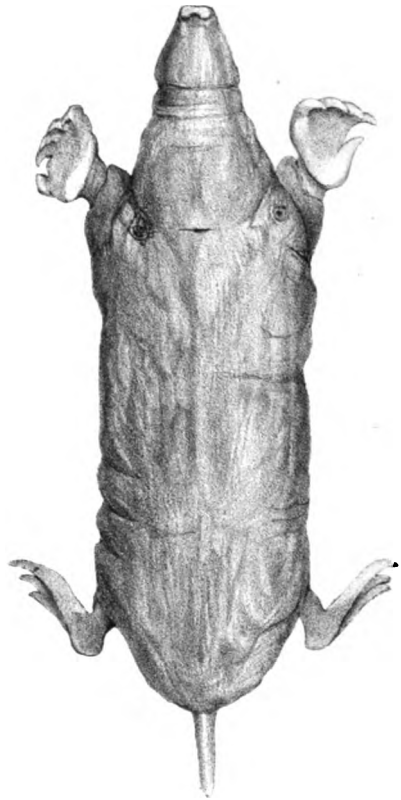

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PLATE I.

Talpa Europæa (young), natural size of the animals of which the examinations were made.

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PLATE II.

Fig. 1.—Permanent dentition—Upper jaw.

Fig. 2.—Permanent dentition—Lower jaw.

Fig. 3.—Canine tooth—Lower jaw.

1, 2, 3 } inc.—incisors.

1, 2, 3, 4 } p.m.—premolars.

1, 2, 3 } m.—molars.

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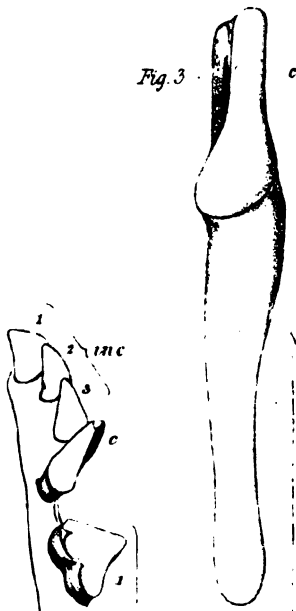

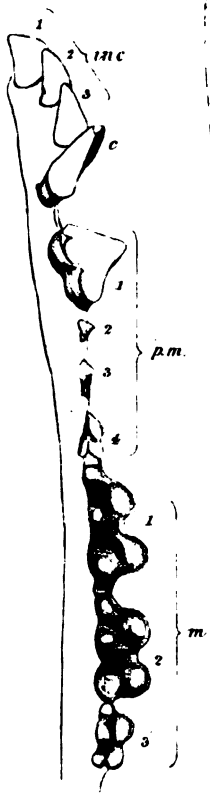

Fig. 2.

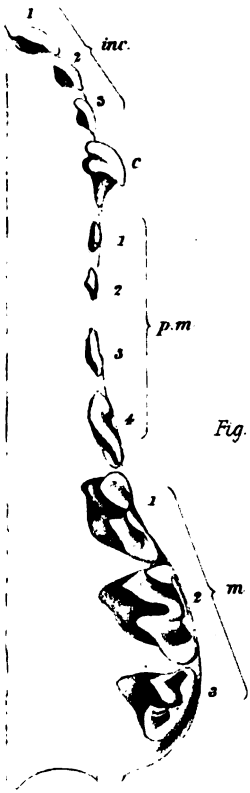

Fig. 1.

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Fig. 3

Fig. 2.

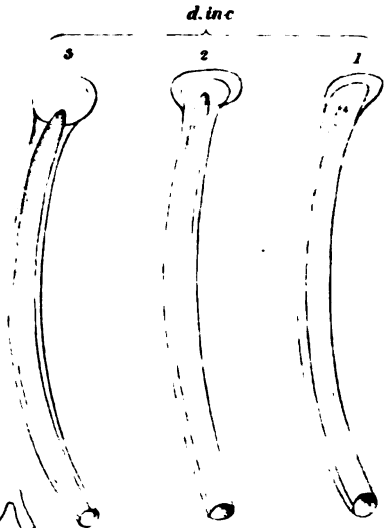

Fig. 5.

Fig. 4

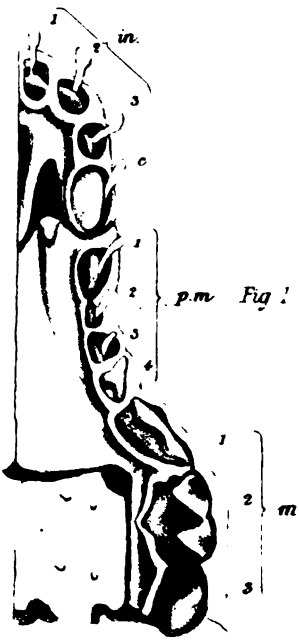

Fig. 1

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PLATE III.

Fig. 1.—Upper Jaw of a young mole, showing the deciduous and permanent teeth in position.

Fig. 2.—1st, 2nd, 3rd Deciduous Incisors—Lower Jaw.

Fig. 3.—*c*, Deciduous Canine—Lower Jaw.

Fig. 4.—1st, 2nd, 3rd Deciduous Premolars.

Fig. 5.—4th Deciduous Premolar.

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PLATE IV.

Fig. 1.—Lower Jaw of the young mole, showing the deciduous and permanent teeth in position.

Fig. 2.—1st, 2nd, 3rd Deciduous Incisors; *c*, Deciduous Canine, with the crowns of the permanent teeth in their natural position.

Fig. 3.—*c* Deciduous Canine.

Fig. 4.—1st, 2nd, 3rd, 4th Deciduous Premolars.

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Fig 1

Fig 2

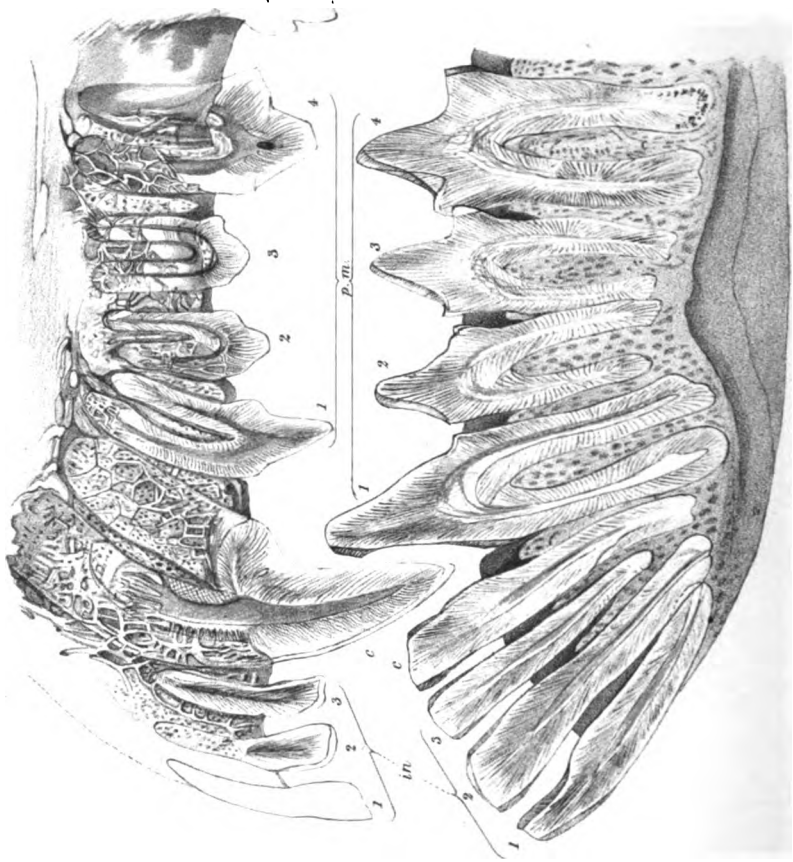

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PLATE V.

Fig. 1.—Longitudinal section of the Upper Jaw, showing the permanent premolars and intermaxillary teeth in position, with the ramification of the capillaries over the alveolar walls.

Fig. 2.—Longitudinal section of the Lower Jaw, showing the permanent premolars and intermaxillary teeth in position, with the ramification of the capillaries over the alveolar walls.

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PLATE VI.

Fig. 1.—Canine Tooth of the Upper Jaw, longitudinal section, reduced from a drawing, as seen under a two-thirds of an inch object-glass.

Fig. 2.—Canine Tooth of the Upper Jaw, horizontal section, reduced from a drawing, as seen under a two-thirds of an inch object-glass.

Fig. 3.—Section of enamel.

Fig. 4.—Section of enamel, showing connection of the enamel with the cementum.

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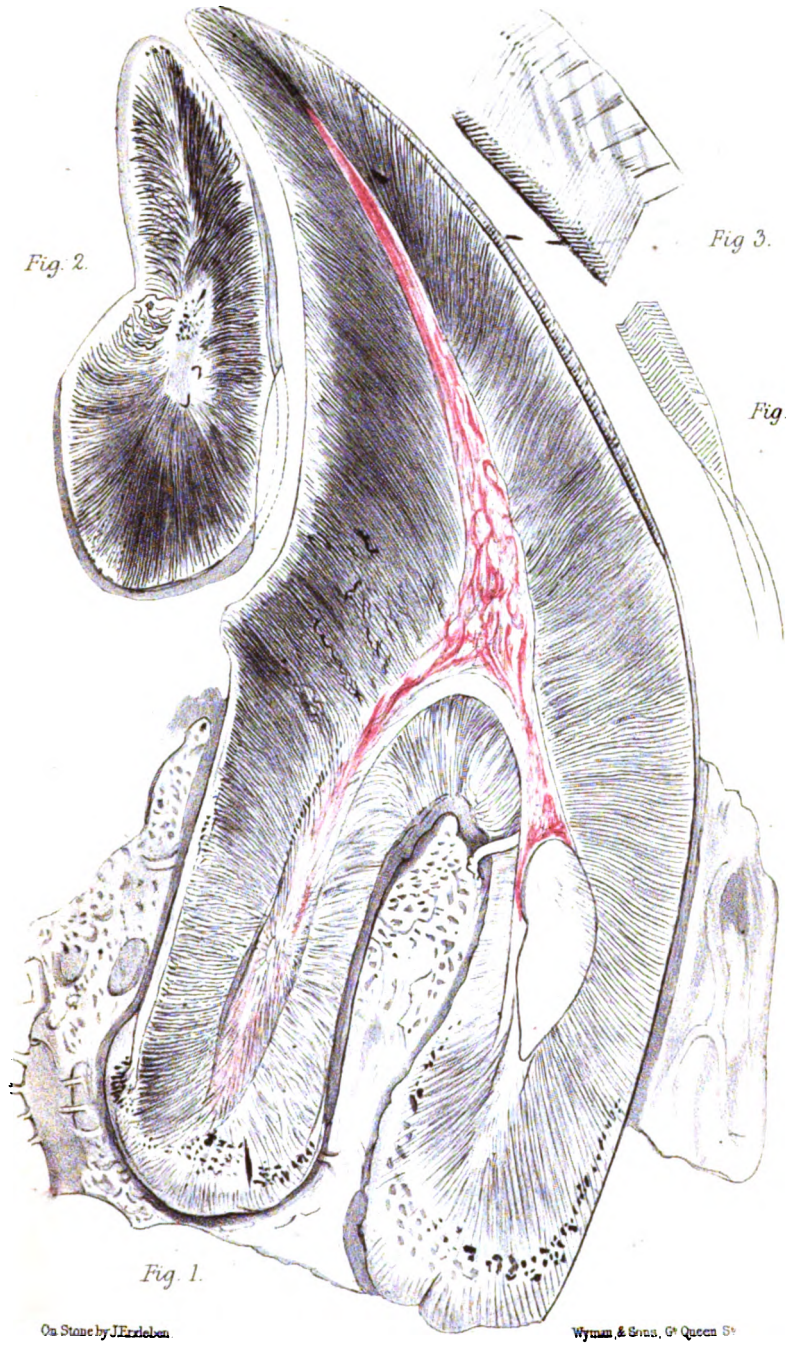

Fig. 2.

Fig 3.

Fig. 4.

Fig. 1.

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GENERAL MONTHLY MEETING.

Monday, May 6, 1867.

G. A. IBBETSON, Esq., President, in the Chair.

The following Gentlemen were elected Members of the Society:—

Mr. John Ellis Mortimer, 12, Great Castle Street, Regent Street.
Mr. John Dearden Bush, M.R.C.S., 16, Hanover Square.
Mr. Henry Harding, L.D.S., Park Square, Regent's Park.
Mr. William Penny Bartlett, L.D.S., Eastbourne-Park Terrace, Hyde Park.
Mr. Frederick Wright, 4, Westbourne Park.
Mr. Robert Bell, L.D.S., St. Margaret Street, Canterbury. (Non-resident.)
Mr. William James Sheils, 16, South Mull, Cork, Ireland. (Non-resident.)

The following Gentlemen were proposed as Members of the Society:—

Mr. E. J. Sylvester, of Worcester.
Mr. G. H. Makins, M.R.C.S., L.S.A. (Honorary.)
Mr. Lionel Beale, M.B., F.R.S., &c. (Honorary.)
Mr. George Busk, F.R.S., &c. (Honorary.)

The following Contributions to the Museum and Library of the Society were made by—

Dr. M'Quillen,—"The Transactions of the Odontographic Society of Pennsylvania."

Mr. Harrington, of Ryde, presented a contribution to the Museum in the shape of two anterior bicuspids of the upper jaw, each tooth having three fangs. The buccal fang was something more than bifid;

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there were two well-developed fangs reaching nearly to the neck of the tooth. One of the palatine fangs appeared to be perfectly formed; the other was not completely formed.

Mr. Bell Longhurst presented to the Society the model of a case, which was interesting as showing the eruption of a canine tooth at the age of 68.

Mr. Harrison exhibited the models of two cases, in each of which there was a well-formed third lower bicuspid—both on the left side. The first, he said, was taken, some years ago, from the mouth of a lady who had been his patient from her childhood. When she had reached the age of 27 or 28, she came to him, after an absence of two years, or thereabouts, to have some teeth stopped; and he then found that she had cut this third, or supernumerary lower bicuspid, since he had last seen her. The tooth being irregularly placed, and therefore likely (as was usual in such cases) sooner or later to produce decay in its neighbours, and being moreover unsightly from this cause, and not a very good one in quality, he persuaded the patient to allow him to extract it, having first taken a model of the case; which he did, he might say, for the express purpose of bringing it before the Society at that time. [The model and tooth were here exhibited together.] The other model was from the mouth of a gentleman who came to him about a fortnight ago to have some upper teeth, which he had lost, replaced. On taking the lower model, for the purpose of the bite, he found that this patient also had a well-formed third bicuspid, which, however, occupied the exact place that should have been occupied by the first molar tooth. With the exception of the molar whose place this bicuspid occupied, this gentleman had his full complement of teeth in the lower jaw, including even the dentes sapientiæ; and as he did not remember ever to have lost a tooth in the lower jaw, and this bicuspid was so regularly placed in the alveolar arch, the question crossed his (Mr. Harrison's) mind, at first, whether it could have been cut originally *instead* of a lower molar; but finding on examination that it was a little overhung by the second molar, he came to the conclusion that it must have been cut subsequent to that tooth, and that in all probability, therefore, this patient must have had the first molar, and lost it early in life, and that this bicuspid had come up afterwards in its place. He thought both cases interesting, but particularly the latter, and therefore had brought them under the notice of the Society.

Mr. W. J. Newman, of Liverpool, brought before the notice of the Society two or three rather peculiar specimens of teeth that he had

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extracted lately. The most extraordinary case was that of an upper molar (left side) which he had extracted, and found the dens sapientiæ attached thereto. A model of this case has been taken by Mr. T. C. Vidler. Mr. Newman also exhibited a model taken from the mouth of a girl, 17 years of age, at the Liverpool Dental Hospital, showing where the temporary teeth had been allowed to remain till that late period.

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Mr. Bridgman read the following Paper—

On Dental Nomenclature.

Mr. President and Gentlemen,—The phraseology, or language, of any science is generally held to be one of the best indications of the position of that science in the scale of advancement; but if this test be applied to our own specialty, Dental Surgery, I fear, would scarcely take that position to which, in other respects, it is fairly entitled. It is true, however, that some progress has been made within the last few years, and that a number of new terms have been introduced, some of which are quite in accordance with our claims to scientific rank; yet we are deficient in that nucleus, or systematic code, around which those terms should centre, and with which they should harmonize and amalgamate. For this systematic framework, or basis, upon which the elements of superstructure should gravitate, we must have recourse to the teeth themselves; we must make the anatomy of the denture furnish us with this nucleus of centralization. But when speaking of anatomy, I do not mean merely the minute and microscopical structure of the component parts of the teeth and their appendages, but include a broader and more comprehensive view of those organs; such an one as shall take cognizance of their sculptural design and their

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architectural arrangements, so as to afford us the means of forming a clear conception of their true character and relative position with respect to the general structure of the oral cavity. The microscopical anatomy of the teeth and their contents has been so well and so fully wrought out, and so ably demonstrated elsewhere, that it will scarcely be needful to touch upon that subject on the present occasion, but to refer more particularly to the *sculpture of the teeth* and their *architectural features*.

If we look at a lower incisor in a child's mouth soon after it has emerged from the gum, we may observe, upon its incisive edge, three small eminences or knobs, separated from each other by two intervening depressions, as shown in fig. 1. These knobs and depressions necessarily produce, in the process of growth, their corresponding ridges and grooves on the two surfaces of the tooth. These three ridges separated by their two intervening grooves showing thus on each surface of the tooth, gives to it somewhat the appearance of being built up of three cylindrical, or, rather, conical rods, compressed together laterally. This feature presents us with the typical form, or key, to the construction of every other tooth in the head. On reference to fig. 2, it will be seen that there is again this trio of eminences, together with their two depressions, only that an unequal degree of development has

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Fig. 1

Incisor

Fig. 2

Cuspid

Fig 3

Bicuspid

Fig 4

Two Bicuspids.

Fig 5.

Lower Molar

Fig 6

Upper Bicuspid.

Fig 7

1st Upper Molar

Fig 8

1st Lower Molar

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caused them to assume different proportions, which is one of the peculiar characteristics of the cuspid. Passing on to fig. 3, a development of the two lateral eminences, more equal than in the cuspid, gives us the form of the corresponding view of the bicuspid.

Then, again, by repeating fig. 3 in duplicate, making one figure overlap the other, as in fig. 4, we have the form of the lower molar. The resemblance of fig. 4 to fig. 5, a first lower molar, is self-evident; thus showing the latter to be, in its strictest sense, a double tooth; that is, composed of two single teeth.

It is not unusual to hear the bicuspids spoken of as "*little* double teeth," which is a misnomer, evidently arising from the mistake of supposing the bicuspid form to be the character from which the title of double tooth is derived, whereas, instead of which, it is thus a repetition of the two bicuspids immediately preceding it, joined together.

The bicuspid, then, although not a double tooth, is composed of two cusps, an outer and an inner cusp, placed in a radial line towards the centre of the mouth. This bicuspidated form is generally, although erroneously, accredited as pertaining only to the bicuspids and molars. If we examine a series of casts of the upper denture, we shall find, occasionally, the cuspids and incisors showing a rudimentary cusp more or less

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developed, sometimes fully so, as in fig. 13, and which is a remarkably interesting case, wherein the temporary central incisor has an inner cusp at right angles to, and nearly as much developed as, the outer one; while others are more or less so, as shown in figs. 14, 15, and 16, all of which are taken from the casts and specimens before us. Hence, if we take a bicuspid and cut it off at the dotted line represented in fig. 9, it will give us the form of fig. 10, a cuspid, and the portion from which the cusp has been thus severed becomes the tubercle that represents it in its less-developed form; so that every tooth partakes, more or less, of this bicuspidated character. Now, whether we treat such formations as shown in figs. 13, 14, 15, and 16, as being abnormal and excessive developments of the tubercle shown in figs. 10, 11, and 12, or whether we deem the tubercle of the cuspid and incisors a sub-development of the cusp, it is perfectly immaterial, inasmuch as the fact and its consequences are the same, and explain to us the origin of those defects in the posterior surface of the incisors as being a part of the system of longitudinal fissures in which such defects are prone to occur.

In the junction of two cusps there is invariably a channel or fissure forming the line of demarcation between them; and this line, occurring between the outer and inner cusp of the bicuspid, being parallel with the length of the

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Fig. 9

Fig. 10

Fig. 11

Fig. 12

Fig. 13

Fig. 14

Fig. 15

Fig. 16

Fig. 17

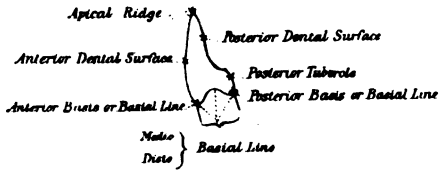


Fig. 18

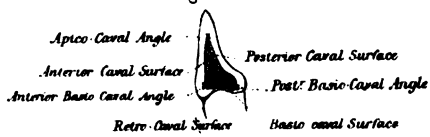
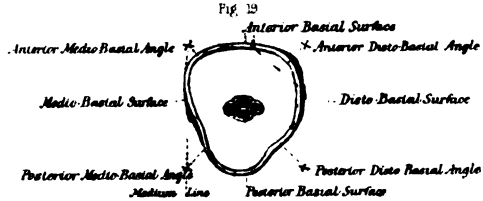
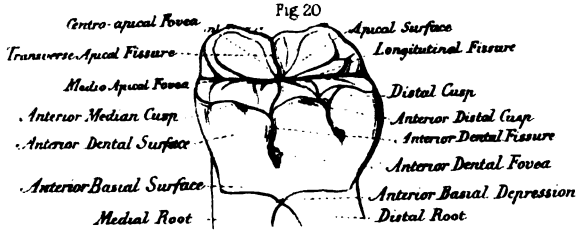


Fig. 19



Basal Section of Central Incisor

Fig 20



1st Lower Molar

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maxilla, is styled *the longitudinal fissure.* This fissure, owing to the ridged and grooved surface of each cusp meeting, is never a perfectly even line, but is more or less angulated and indented by the approximation of these irregular surfaces, in proportion to the degree of their unevenness. Hence, bearing in mind the fact that every outer and inner surface of each cusp has its three ridges and two grooves more or less developed, we are enabled, from such circumstance, to map out these sinuosities and account for their imperfections. Thus, in the slightly varying proportions arising from an unequal development of the ridges, an imperfect antagonism is produced, and minute openings in the fissure are the result; but, in addition to these accidental defects, there are certain indentations that are constant and normal, which it is proposed to designate "*foveæ*," or pits.* There is also one distinctive character in this systematic arrangement of structure that demands our special and attentive consideration, on account of its great practical importance. Fig. 6 is intended to convey some idea of the plan upon which, in the upper bicuspids, the inclined faces of the cusps are made to combine. The three ridges of the inner face of the outer cusp

* The occurrence of imperfections in some characters of teeth more than in others, and the probable cause for it, was pointed out by the author in a paper on "Lateral Pressure," read in 1859, and published in the second volume of the "Transactions," p. 172.

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converge to the centre, while the two lateral ridges of the inner cusp diverge and pass outwards outside and beyond the line of fissure, so as to enclose the three opposite ridges between them, and *thus form a border to the tooth* as well as a perfect boundary to the terminal ends of the fissure, as at A, A. The practical lesson to be derived from this arrangement is, that, in making good the defects of a fissural line, *if we stop short of these natural boundaries, we run the risk of only half accomplishing our object.*

In the compound surface of an *upper* molar, it is not easy at first to recognize the corresponding forms of the two bicuspids, unless a strongly-marked specimen, such as fig. 7, be obtained, when the reason for this obscurity will be readily perceived: it will be seen that the border A of the outer cusp unites with the border B of the inner cusp, and thus forms an oblique ridge across the centre of the tooth, dividing the surface into two unequal proportions.

In the lower molars we have a much more readily recognizable formation. We very commonly find a transverse fissure separating the surface into two nearly equal divisions, as at fig. 8, which again bear the corresponding features of the two neighbouring bicuspids, the peculiarity of which is, that as the *second* lower bicuspid has *three cusps*, we have at its distal half, corresponding in position to the second bicuspid, a

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fifth cusp to the molar. Nor is this the only correspondence; for while the root of each lower bicuspid is single, the lower molar has normally but two roots; yet, as the *first upper* bicuspid has a bifid root, so has the upper molar three roots to correspond.

The first commencement of the tooth papilla in the fœtus is marked by the formation of the matrix of the three eminences, where, in the incisors, their production is simultaneous; but in the cuspid they are successive. Hence, in this we are enabled to trace the origin of those supernumerary teeth, occurring among the incisors chiefly, which, by their simple and conical form, show them to be thus a misplaced exuberant growth; *but the eminence, growing on in a detached state*, forms the pin-teeth in question. On the other hand, the junction of single teeth, like the union of two bicuspids to form the molar, sometimes occurs among the incisors and cuspids, an example of which is before us, showing that these laws of formation have also their occasional departures from their restricted course. It must also be remarked that the resemblance of a molar to its bicuspids is most strongly marked in the first, less so in the second, and least of all in the third molar.

It has been necessary to allude to this duplex formation of the molar in order to account for the peculiar arrangement of the transverse fissure, and its extension into the adjoining surfaces of the

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tooth. In some instances, the borders of the approximal edges of the two conjoined crowns are very fairly developed in the central portion of the tooth in conjunction with the fissure, thus dividing the longitudinal fissure into two portions separated by these terminal boundaries. In other cases these central borders are wholly absent, when the line becomes a deeply-indented fissure, with more or less imperfections in the central fovea which is formed by the crossing of the two fissures, and where decay is almost certain to arise.

Since we have become acquainted with these laws of structural formation, we have derived so much advantage from the knowledge, that I venture to dwell more upon this point than its connection with the subject would seem to justify; but as the remedying defects in the fissural line is one of the most frequent, as well as one of the most beneficial services we are called upon to render, and as it becomes valuable or valueless in proportion as it may prove successful or otherwise, any suggestions that can tend to secure the former can scarcely be deemed out of place while treating of the cause and nature of those imperfections. It is a common occurrence to meet with teeth having from one to three, and even as many as four gold plugs in the surface, and yet other portions of the fissure have become decayed subsequently and rendered the whole a failure.

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Now it must be an obvious conclusion to arrive at, that as all these defects, although not noticeable as decay, originally existed as imperfections, and might have been made good in the first instance had they been recognized;—in fact, the first stopping would then have included not merely the actual spot of decay, but all the defective portion of the fissure wherein decay could subsequently occur, as well. This radical treatment we have now adopted in our own practice for some time past, and not a single instance of a second stopping being required on the same surface has yet been met with in teeth so treated. Knowing where the natural boundaries of the fissure ought to be found, and making these the limitation of the plug; then by opening out and making good all intervening portions of the fissure, we take the most effectual steps possible to secure success, and to attain this no amount of trouble can be deemed superfluous. In some portions of the fissure no distinct terminal border will be found, as in the posterior surface of the upper molars and the distal end of the divided fissure enclosing the fifth cusp on the lower molars; and it then becomes necessary to remove the dentine beneath, and replace it with the plug wherever the enamel cannot be spared.

To return from this digression, we have next to consider the character and position of the teeth as a part of the architecture of the mouth.

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We divide the tooth into its crown and its root, or roots. This division is not an arbitrary one, for it is following the precedent nature has set us. The crown of the tooth is first fully formed of soft material, and subsequently becomes hardened. At this stage it rests *upon* the surface of the papilla, which ultimately becomes the tooth-pulp; and it is at this period a continuation of the epithelial covering of the gum: in fact, at this stage, it corresponds most completely with the dermal covering of the crustaceans, and, like the crabs, when the teeth have to be enlarged, the root is again absorbed, and the crown returns to the preceding stage before it can, like the crab's shell, be cast off to make room for its enlarged successor.

Thus, on the completion of the crown, the root then begins to form, and encloses the papilla within it, so that the root is in reality but a shaft to support the crown. In some forms of organic life the crown remains attached to the epidermal layer, and in others it becomes anchylosed with the osseous skeleton; but in the class Mammalia, the root or shaft penetrates into the cancellous tissue of the maxilla, and is thus rigidly supported against the force and pressure it has to sustain.

The terms alveolus and alveolar socket are often used with some degree of confusion. The true alveolar socket is a conical cavity composed of a plate of the cancellous tissue fitting closely

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around each respective root contained within the maxillæ. This alveolar socket is then sustained between the two lamellæ of the alveolar process pertaining to the maxilla; and it should be noticed that this cancellous tissue crops out between each tooth,—in fact, forms the septum,—and by means of the foramina within, it allows the vessels of the papilla to communicate directly with the gum above; thus forming a short route to the tooth-pulp.

We have the most indubitable evidence that the tooth is nothing more than a hard-covered papilla; and although we look upon the teeth as independent organs, of a structure peculiarly *sui generis*, there is every reason to consider them but as one component of a more comprehensive papillary class, the other portion of which in the human mouth is to be found on the tongue.

We have three natural divisions into which the teeth may be separated:—first, the incisors; next, the cuspidates, comprising the cuspids and bicuspids; and thirdly, the molars or double teeth.

Upon the tongue are three other sets of papillæ singularly corresponding in character and position, set for set, with the three different kinds of teeth. Thus, on the edge of the tongue, at its tip, there are the fungiform papillæ, which, in form, are not very unlike the pulp of an incisor tooth, and with which in position they are thus so closely associated. Next to these, there are the conical and

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filiform papillæ, forming the second division, and answering to the cuspids and bicuspids in similarity of form and position; and, lastly, there are beyond these and on a line with the molars, the circumvallate papillæ, which, as their name, "walled round," implies, are double, like the molars. Whether there be any sympathetic connection or reciprocity of action between these soft-covered papillæ of the tongue and the hard-covered papillæ of the jaws, is difficult to determine; but my own impression is that something of the kind does exist, although to what extent I am not yet prepared to hazard an opinion. There is also this peculiar feature, that these soft-covered papillæ of the tongue in the feline tribe—the lion, for instance—become encrusted with hard coverings like the teeth, and in some degree serve the same purpose.

It may have been observed that the word *fang* has not been made use of. The omission of this term has not been without intention; for although long custom has rendered it almost a household word, it is not the less objectionable. Before a patient, it is policy to convey our meaning in the mildest terms we can put it, and to avoid the use of any word that can excite fear, or even the slightest alarm. The word "fang," in its ordinary sense, is most decidedly a terrorist. The very sound of the word conveys an idea of something dreadful; and its meaning, as explained in our

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English dictionaries, is illustrated by examples of the terrible; as, for instance, from Dryden—

"Prepared to fly,
The fatal *fang* drove deep within his thigh;"

From Addison—

"Then charge, provoke the lion to the rage of *fangs* and claws."

Then again—

"As adders *fanged*."

But it may also be questioned whether the root of a tooth be *rightly* designated by the word fang, as this more strictly refers to the *crowns* of the incisors and cuspids, or to quote further from Johnson, the latter are defined as "long tusks of a boar, or other animal, by which the prey is seized and held;" and again, "some creatures have overlong and outgrowing teeth, which we call *fangs*, or tusks." The word "root" expresses not only all that we understand as referring to the so-called "fang," but it also implies something more than is conveyed by the latter term. Hence, in addition to its being a word little likely to excite apprehension in the mind of the patient, it is correct, in its present acceptation, as well as in accordance with the commonly understood acceptation of its meaning. These may be considered fair reasons for suggesting its adoption; and, after several years' trial, I find it answer so well, that I have no desire to reinstate its deposed predecessor.

Considering the teeth, then, in their character

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of papillæ, it will be necessary, in classification, to separate them from ordinary soft-covered papillæ as a sub-class, or order, with the distinctive character of being *hard*-covered. They may then be defined as *maxillary*—series *uninterrupted*; *pulp-enclosed—enamel exterior*, and *entire*.

Then, again, with regard to their form, this may be described as heteromorphous, or *various*, and they may be separated into three genera and four or five species. Thus—

Genus 1, species 1, comprises the incisors.

Genus 2, species 1, the cuspids.

„ species 2, the bicuspids and tricuspids; or the latter might be separated into a third species (species 3, the tricuspids).

Genus 3, species 1, the molars; and these may be tabulated in the following formula:—

$$\textit{i.e.,}\ \text{i.}\ \frac{2}{2} + \text{c.}\ \frac{1}{1} + \text{b. \& t.}\ \frac{2}{2} + \text{m.}\ \frac{3}{3}\ \text{in}$$

each maxilla;

$$\text{or, i.}\ \frac{2}{2} + \text{c.}\ \frac{1}{1} + \text{b.}\ \frac{2}{1} + \text{t.}\ \frac{0}{1} + \text{m.}\ \frac{3}{3}$$

Having now passed in review the various distinctive characters of the teeth, or such features pertaining to them as require to be kept in view and discriminated, it remains to consider the terms

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by which these points will be most suitably designated.

There is scarcely any other part of our nomenclature so confused as that which relates to the various terms by which certain portions of the external surface of the teeth are designated; thus, we have labial, lingual, palatine and buccal, medial and distal, external and internal, exterior and interior, outer and inner, anterior and posterior, all applied, at one time or another, to the four vertical surfaces of the teeth. It must be evident that all these terms are not required; but that one set of four could be made to serve every useful purpose, if those four could be definitely agreed upon.

In describing the approximal surfaces, the medial line, dividing the central incisors, is taken as the starting-point; and nothing can be more appropriate than to define that approximal surface which forms part of this line as the *medial* surface of the tooth. Then its opposite, or that most distant from the medial line, is obviously its *distal* surface (from *distans*, distant, far asunder, &c.)*

* This medial surface is also sometimes called its *anterior* surface, but how this can be applied to the incisors is not clear: that it may be used for the medial surface of the bicuspids and molars is reasonable, as this surface is that which is presented to the anterior portion of the denture; but as the surface that is parallel with this surface of the molars is the labial surface of the incisors, this, instead of the other, would naturally be deemed the anterior surface of the incisors; and thus we should have one surface of the molars and another of the

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Next to these we have the labial, the buccal, and the lingual surfaces, which it will be necessary to consider in a twofold character.

First as a whole, forming a continuous wall of teeth from one end of the denture to the other, and presenting surfaces external and internal as regards the line; and then, as individual teeth, separate from any connection with the form of the denture.

The confounding of these two conditions would seem to account for the greater part of the misapprehension and confusion with regard to the terms made use of; as, for instance, applying the terms external and internal, exterior and interior, outer and inner, &c., to the *individual teeth*, when they apply only to the *figure* which the teeth, collectively, constitute. Take a transverse section of any tooth at its basis, and it will be seen to present two lines of enclosures (fig. 19); one forming the exterior or periphery of the tooth, the other the inner or internal wall of the pulp-cavity. Every portion of the outer surface is external to the smaller or internal surface. If we apply the term "interior" to the lingual surface, by what term can we then designate *the real interior of the tooth?* We have only the terms

incisors answering to the same term. By adopting the very suitable "medial" and "distal," which are too palpable and too simple to create confusion, we liberate the terms "anterior" and "posterior" for another purpose to which they are better adapted.

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"anterior" and "posterior" to fall back upon, which rightly designate these surfaces, and which will apply indiscriminately to the teeth or to the denture. The surface that is presented forwards is naturally the *anterior*, while that beyond it becomes the *posterior* surface; and these apply as truly to the molars as to the incisors. We shall then have "anterior" in lieu of labial and buccal, and "posterior" for lingual and palatine; while the terms "external" and "internal," &c., may serve to designate the outer and inner lines of the denture, when speaking of the teeth *collectively*. The terms outer and inner, exterior and interior, external and internal, will also apply, with equal accuracy, to the two lines of cusps as pertaining similarly to the line of denture.

The crown of a tooth may be considered as being represented by a solid cube; consequently, there are yet two other surfaces remaining to be provided for; namely, its base and its summit. Its base, or basial surface, is necessarily that surface which rests upon the upper surface of the papilla during the formation of the crown of the tooth, prior to the growth of its root. Its summit is the opposite, or grinding surface. To the latter, the term "apicial" has sometimes been applied. The sound of the word, however, is a great objection to its use; in addition to which, with regard to the meaning implied, it is not strictly correct. "Apex, apicis," means simply *an apex*. "Apicatus," *having*,

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or *wearing an apex, tufted*, would seem to be the more appropriate term, as it would then give us "facies apicata," or apical surface, *a surface having one or more apices*, which definition applies to all but the incisors; and here, as it becomes merely a ridge instead of a surface, we have only to adopt "apical *ridge*" for "apical *surface*," to render the term suitable to all.

We shall then have—

Anterior dental surface;
Posterior dental surface;
Medio-dental surface, or medial surface;
Disto-dental, or distal surface;

together with the basial and apical surfaces, designating the six surfaces of each tooth.

Where the anterior dental surface abuts upon the medial and distal surfaces, we have an imaginary line, which in the cube is an edge, and would be defined by a combination of the two terms; as, for instance, the anterior distal, or anterior medial, edge or angle; and with the posterior, the posterior distal, and posterior medial, edge or angle (fig. 19). Each surface may again be divided into its three regions, or areas—the apical, the central, and the basial area,—each occupying about one-third of the surface.

The incisors (fig. 17) would be described as having an anterior and a posterior dental surface, a posterior tubercle, a medial and a distal surface,

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a basial line encircling the cervical portion of the tooth, and an apical ridge, the latter composed of its medial, central, and distal eminences, together with the medial and distal notches by which the former are separated.

These terms also apply to the cuspid, with the one exception of the apical ridge; instead of the three eminences being equal, the central becomes developed into the central cusp; and for the bicuspids, the posterior tubercle becomes developed into the posterior cusp; while for the double teeth we have a medial and a distal half, with all the terms used for bicuspids in duplicate. In addition to these, however, there is now, in the line of junction, a transverse fissure extending over the anterior dental surface, and terminating at or about its centre, in the anterior dental fovea (fig. 20), but on the posterior surface rarely with, but generally without, any such fovea or distinct ending (fig. 20).

The transverse fissure crossing the longitudinal often gives rise to a very considerable fovea directly in the centre of the apical surface of the lower molars; but sometimes there is one on each side of a partially developed line of borders accompanying the transverse fissure. In the one case it becomes simply a central fovea, in the other the medio-*central* and disto-*central* fovea, together with the medial and distal foveæ at the two ends of the longitudinal fissure in each case.

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With regard to the root of a tooth, in its terms its position will be reversed with respect to its crown; its basial surface will naturally be its junction with the crown, while its tapering end will be its apex; and here the word "apicial" as applied to the *apicial foramen*, will be suitable and correct.

As it has been proposed to term the lowest third area of the anterior dental surface its "anterior basial area,"* it would be well to reserve the appellation "cervical" for the root *below* this part.

In the basial line at the division of the two roots we have also a "depression," anterior and posterior, in the lower molars, the anterior basial depression, &c.

It will be unnecessary to particularize further, as the framework of terms proposed may be readily extended and filled up, the parts themselves suggesting the combinations required.

As *cava dentium* signifies "hollow teeth," the word "cavum," *a hole*, or *hollow place*, will suffice to denote the interior of a cavity of decay. Then, as every cavity will have its side-walls and inner surfaces, its angles and its floor, these may readily be designated by attaching the term "caval" to that of the part which corresponds to it (fig. 18). Thus, in an approximal cavity of either medial or distal surface, instead of the anterior *dental* surface, the

* Or basial area of anterior dental surface.

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corresponding surface of the cavity would be the anterior *caval* surface; and so on for the others. The only addition required will be for the floor or surface most distant from the orifice. The word "retro," *behind, back, backward*, will give all that we require for this, and we shall then have the *retro-caval* surface for the floor or back of any cavity.

In the anterior dental fovea of the lower molars it is not uncommon to find decay; but decay also occurs not unfrequently along the basial line of the same surface, and even extending into the medial and distal surfaces; yet, hitherto, all have been classed as "buccal" decay, without further distinctions. The terms proposed will give us the means of defining the character of decay with the utmost precision in every case where decay can occur.

With respect to the third molar, the absurd nonsense connected with these so-called wisdom teeth renders it highly desirable it should be discountenanced as much as possible, to disassociate such relics of superstition from a science claiming to rank among the first in the land. Nor is this the only expurgation needed; the appellation "canines," or *dog-teeth*, is not flattering to our humanity, any more than the simile of "calf's teeth" to the incisors, or "monkey's teeth" to the molars. Let the comparative anatomist, too, reserve his "premolars" for the quadruped, and

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not bring us down to *their* level; for as man ranks above and enjoys the distinction of constituting a separate order by himself, so let him strive to maintain all the distinctive characters he can legitimately lay claim to, as tending so emphatically to mark his superiority over the brutes of the creation.

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GENERAL MONTHLY MEETING.

Monday, June 3, 1867.

G. A. IBBETSON, Esq., President, in the Chair.

The following Gentlemen were elected Members of the Society:—

Mr. James Oakley Coles, 68, Wimpole Street.
Mr. Simeon Haslam, 50, Berners Street.
Mr. Edwin Frederick Lane, L.D.S., 4, Bedford Place, Russell Square.

The following Gentleman was proposed as a Non-resident Member of the Society:—

Mr. Ebenezer Apperly, L.D.S., Stroud, Gloucestershire.

The following Gentlemen were recommended by the Council for election as Honorary Members of the Society:—

The Earl of Enniskillen, F.R.S., &c.
Sir Philip Grey Egerton, Bart., F.R.S., &c.

Mr. Vasey presented to the Museum a model of the mouth of the *Otaria Hookerii*, recently taken from the dead subject at the Zoological Gardens.

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Professor Owen, F.R.S., &c., read a Paper—

On the Dental Characters of Genera and Species, chiefly of Fishes, from the Low Main Seam and Shales of Coal, Northumberland.

Having been honoured with a request by the President, on the part of the Council, of the Odontological Society of London, that I should communicate a subject in Odontology to one of the meetings for scientific business, I have selected from a supplementary MS. chapter for a second edition of my "Odontography," some materials not heretofore made public; and I feel pleasure in this opportunity of co-operating with the practical members of the Society in their purely scientific aims to establish their most useful branch of surgery on the broad basis of Hunterian physiological principles, as deduced from a survey of the modifications of dental structures and phenomena throughout the animal kingdom.

The present contribution is but a small one, but the thought that "every little helps" encourages me to offer it; and the facts are afforded by a part of the great Vertebrate series most remote from that with which the Society is practically concerned. Moreover, the species from which my descriptions and illustrations are derived have long since passed away from the theatre of animal existence. I have, therefore, to

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bespeak the indulgence and favourable attention of my auditory.

The following are the circumstances under which I have been enabled to make the observations about to be detailed:—

I have been favoured from time to time, by Mr. T. Craggs, of West Cramlington, and Gateshead, Northumberland, with sections of coal from the "Low Main Seam," or from the "Shales" overlying that seam, at West Cramlington, showing portions of dentigerous bone and detached teeth, admirably prepared for microscopic examination. From these I have selected specimens that offered sufficiently well-marked differences from previously characterized genera of fishes from such formations; and the results of my observations and comparisons I have now the pleasure to communicate to the Society.

So far as such materials have reached me, I believe that to Mr. Craggs belongs the merit of the discovery of these accessions, if I have rightly construed their nondescript character, to Carboniferous Palæontology. Mine has been merely the task of comparison and description of the fossils, to the collection and preparation of which he has devoted much time and peculiar skill; and I feel deeply indebted for the opportunity thus kindly afforded me of studying several unexpectedly novel modifications of dental form and structure.

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Genus—DITTODUS,* Ow. (Twin-tooth).

Species—*Dittodus parallelus*, Ow. (Parallel twin-tooth). Plate I.

I propose the name *Dittodus* for a genus represented by a section of a part of a bone, probably dentary, and by specimens of detached teeth, which, together with those preserved in the section of the bone (Plate I., fig. 1), have the peculiarity of a double crown rising from a common base.

It is not one of those instances, of which I have seen several in both Fishes and Batrachians, of two contiguous but distinct teeth, separated from another pair by an interval, from which a similar pair of teeth have been shed; but the hard dentine of one crown is directly continued at the side of the base next the contiguous crown into the corresponding tissue of such crown (ib., fig. 2, *a*); while the dentine of the opposite or remote sides (ib. *b*, *c*) extends and is gradually lost upon the common osteo-dentinal base, (ib., *e*) or the osseous tissue of the supporting bone (ib., *o*). Thus the two crowns are organically connected together, like the Siamese twins, and are not merely in close juxtaposition; whence the term "twin-tooth" (*Dittodus*) suggested itself as de-

* Gr. δισσός twin or double, ὀδούς tooth.

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scriptive of the main and obvious distinctive dental character of the genus.

That this genus is referable to the class of Fishes I do not positively affirm, but it is in the highest degree probable, from the character of the osseous tissue in the portion of dentigerous bone to which a sufficiently high magnifying power can be applied: the alternative would be a Batrachian one.

I have, however, seen no ganocephalous or labyrinthodont bone with so complete an absence of Purkinjian or radiate cells, or with so large vascular canals in proportion to the hard tissue traversed by the plasmatic tubules:* these also are free from dilatations, or nearly so. At a short distance below the alveolar stratum of bone, the vascular canals dilate into, or communicate with, larger vacuities, which may have contained unossified cartilage.

The osteo-dentine, occupying part of the coronal cavity (figs. 2 and 3, *p*), and forming the common basis of both crowns beneath the thinning off of the hard exterior dentine, is directly continuous with the less dense osseous tissue of the supporting bone itself.

Four pairs, or four of the twin-teeth, and the bases of as many succeeding twin-teeth, are preserved in the section (Plate I., fig. 1, *a*—*h*), the length of which portion of bone is 9 millimeters

* "Anatomy of Vertebrates," vol. i. p. 21.

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(ib., *a*, nat. size); the length of the crown of the twin-teeth is four-fifths of a millimeter; the breadth of each crown above the coalescence is one-sixth of a millimeter; the breadth of the common base is about half a millimeter.

The twin-teeth are divided from each other, in what represents an alveolar border of the bone, by intervals of about the length of the crown, and diminish, apparently, with that length, as they recede in position.

The first twin-tooth (fig. 1, *a*) is at the fore end (*m*) of the section figured; but this is not the natural free termination of the dentigerous bone. Only one of the crowns of this tooth is entire: it is more curved and more acute than those of the succeeding teeth. In the next twin-tooth (*b*) both crowns are entire, of nearly equal length, slightly recurved, with sub-obtuse summits: it may be, however, that the section has taken off the extreme apex; for the pulp-cavity, though contracted, reaches to the preserved end. In the third twin-tooth, with both crowns preserved (*c*), some deviation of the section from their longitudinal axis seems more clearly to have happened, as the pulp-cavity opens rather behind the remaining apex (ib., fig. 2, *b*); and such obliquity in the section may also be inferred from the removal of part of the dentine from the fore part of the base of the anterior crown (ib., *c*). In the fourth twin-tooth (fig. 1, *d*) only the basal half of the

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crowns is preserved. But in this series of four twin-teeth it seems that the confluence of the dentine at the contiguous sides of the two crowns takes place earlier, or further from the common base, as they are situated further back upon the jaw. Whether the separated proportion of crowns progressively diminishes as the teeth are situated further back, my present materials do not determine. But Mr. Craggs informs me that in one of his sections "with the teeth in pairs, in another part of the jaw, they stood singly, were further apart, and were considerably larger."*

Each crown of a twin-tooth is composed of an outer wall of unenamelled hard dentine, inclosing a pulp-cavity which at the basal third of the crown equals in breadth a semi-diameter of that part, but becomes relatively narrower as it ascends, yet nowhere contracting to one-third of the tooth's diameter at the same part or transverse level. The pulp which occupied this long and wide cavity began, as usual in fishes, to be ossified at the base of the crown; and, in the third twin-tooth, the osteo-dentine occupies rather more than the basal half of the coronal pulp-cavity (ib., figs. 2, 3, *p*).

The parietal dentine is of that very compact kind which is found in the teeth of many osseous fishes, and is exemplified in plates 43 (*Microdus*), 50, and 52 (*Scarus*) of my "Odontography." The dentinal tubules of *Dittodus* are $\frac{1}{10,000}$th of

* Letter dated West Cramlington, June 22nd, 1865.

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an inch in average diameter, and are thus less than half the diameter of those in man. They are arranged very closely. Leaving the pulp-cavity, they make a short and slight primary bend, with the convexity toward the apex of the crown; then a short bend in the opposite sense, and again as in the first curve, but in a minor degree, maintaining a general course at almost right angles to the exterior of the tooth. Although they incline peripherally toward the apex in approaching that part, it is in a very slight degree; and as none of them have assumed a direction parallel with the axis of the tooth, I infer from this circumstance, also, that the apical end is wanting from the crown.

There is no ganoine or fish-enamel on the twin-teeth here preserved.

The osteo-dentine is traversed by large and irregular medullary canals, the widest being usually along the axis of the mass, representing a remnant of the original pulp-cavity, which is sometimes interrupted by extension of the finely tubular bone, as in the part (*x*) of the twin-tooth magnified fifty diameters in Plate I., fig. 2.

This ossified part of the pulp is thick and dense at the common base of the tooth (ib., *a*, *e*), and is less excavated by medullary vacuities than is the subjacent bone (ib., *o*, *o*), in which the osteo-dentine seems to degenerate. The tubuli of the osseous part of the osteo-dentine are directly con-

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tinuous with those of the coronal or parietal dentine at some points at the base, where the latter is thinning out, as at *b'*, fig. 3. Higher up the basal orifices or "lumina" of the dentinal tubules open into contiguous medullary cavities of the osteo-dentine; and, higher still, or nearer the apex, they open, as usual, upon the surface of the pulp-cavity.

The question whether these "twin-teeth" be "oral" or "dermal" arose at first glance, and was kept in view during the course of the investigations of which the main results are above recorded. To its solution I now turn my endeavours.

Detached teeth—the more common condition in which such fossils occur on coal-plates—seldom speak decisively one way or another; but the little that the twin-teeth so detached do say is in favour of the maxillary choice. I note, for example, the uniform absence of an entire, distinct, and well-defined expanding base of osteo-dentine, or bone sustaining a solitary twin-tooth, in the way that the tooth-like dermal spine is supported in the skin of *Raia clavata*,* and in the way that the blunter shorter dermal tooth is supported, distinct from its close neighbours, in the "shagreen" of many sharks. The base in all the specimens of detached twin-teeth is broken, or the

* "Anatomy of Vertebrates," 8vo, vol. i., p. 548, fig. 365.

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portion of adherent bone is irregular, and has been broken off from another portion.

The demonstrations of more than one twin-tooth attached to the same piece of bone are not rare. The specimen selected for representation (Plate I., fig. 1) is a section of such portion of bone supporting at least eight twin-teeth, and the shape of this piece of bone, prior to its being submitted to section, was such as to lead Mr. Craggs to call it a "jaw." *

Now, on this specimen may be based considerations which tend more decisively to support the high probability, at least, that the teeth attached thereto were oral, and the bone either mandibular or maxillary. The eight twin-teeth are marginal and are "serial," or succeed each other along the same line: dermal spines are scattered irregularly. These twin-teeth show so much uniformity of curve of crown in that series as to indicate a "fore-end" (*m*), and a "back-end" (*n*), of the elongated piece of bone supporting them: the concavity of the coronal curve, according to the general analogy of bent-teeth in fishes' jaws, being backward or throatward. The degree in which that uniformity is departed from, or the gradation in the bend of the crown, whereby the teeth of the present species of *Dittodus* grow straighter as they recede in position, is significant: the curved tooth-like spines, on detached bony plates, in

* See note, p. 328.

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Raia clavata, besides being irregularly arranged, point in diverse directions. Still more significant is the progressive diminution of the intervals of the twin-teeth as they approach what may be inferred to be the throat-end of the piece of jaw. From the sum of the foregoing observations it is reasonable to infer that the bone, Plate I., fig. 1, is part of a jaw, and that the piercing, prehensile weapons it supports are true teeth.

Nothing more noteworthy occurs to me to impart as to the dental characters of the present species of the genus *Dittodus*. But whatever doubt may cling to, or flaw be detected in, this attempt at determination, sufficient, I trust, has been recorded and illustrated to enable microscopic investigators of other carboniferous localities to recognize the genus, and perhaps the species, if they should be so fortunate as to find specimens of teeth, whether detached or adherent to bone.

The genus *Diplodus*, Ag., was founded upon teeth of the type of those of *Hybodus*, but generically distinct, by different or reverse proportions of the medial and lateral cones. The teeth of *Diplodus* do not, as the name implies, or might suggest, consist of a pair of conical crowns, but of three, of which the mid one is barely half the size of the two lateral ones, and may even be less than half. Moreover, the lateral and longer cones are not always single on each side the median one; as

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many as five have been seen upon a common base or root.*

In *Diplodus gibbosus*, the type species (fig. 1, A & B), the teeth differ from those of *Dittodus*

Fig. 1.

Tooth of *Diplodus gibbosus*.
A, nat. size; B, another specimen magnified (after Agassiz).

not only in size and shape, but also in structure.†

The teeth of *Diplodus minutus*, Ag., are larger and the lateral cones broader than are the crowns of *Dittodus parallelus*.

No specimens of *Diplodus* have been seen attached in a row, or serial number, to a single bone.

* "Dans les genres (des Hybodontes) que nous venons de décrire, le cône médian l'emporte sensiblement sur les cônes latéraux, et se developpe en quelque sorte à leur detriment. Dans le *Diplodus* c'est tout le contraire qui a lieu et les cônes secondaires se développent au détriment du cône médian qui égale à peine la moitié d'un cône lateral, ou est même réduit à un simple bouton. Les cônes latéraux sont de nombre variable, j'en ai vu jusque à cinq sur une racine."—Agassiz, "Recherches sur les Poissons Fossiles," tom. iii., p. 204.

† "Sous le rapport de la structure microscopique il (*Diplodus*) se rapproche assez du genre *Sphenonchus*."—Ib.

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To the descriptions and figures of *Diplodus*, Ag., the palæontologist would first refer in his comparative labours to determine the fossil "twin-teeth," and the distinction is at once obvious.*

Species — *Dittodus divergens*, Ow. (Diverging twin-tooth). Plate II.

I give this name to the species represented by teeth of the type figured in Plate II., fig. 1, on account of the divergence of the two crowns from their common base.

In the section figured, the generic characters of *Dittodus* are shown, in the absence of any trace of middle lobe, in the continuation of the parietal dentine of the contiguous sides of the two crowns (*d*) into each other at the upper part of the osteo-dentinal base, and in the extension of the dentine from the remote sides of the crowns (*b*, *c*) down the exterior of such base, where it is gradually lost. The specific distinction from *Dittodus parallelus* is shown, not only by the direction, but by the shape and proportions of the two crowns, which are relatively shorter and broader. The parietal dentine forms a greater proportion of the crowns,

* A critic of the "Abstract" of this Paper has affirmed of *Dittodus*, "This is undoubtedly *Diplodus* of Agassiz, and is not a tooth but a dermal spine."—"Geological Magazine," August 1st, 1867, p. 379.

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with concomitant contraction of the pulp-cavity, and a minor amount there of osteo-dentine; and, with the centripetal extension of the calcification of the pulp, according to the process resulting in hard dentine, the number of tubules diminishes in the same direction, and they form, by successive unions, a series of trunk-tubes of greater length and diameter (Plate II., fig. 2) than any in the preceding species. The parietal dentine in *Dittodus parallelus* answers to the peripheral half of that of *D. divergens*, in regard to microscopic structure. And yet the condition of the several twin-teeth in *D. parallelus* (Plate I., fig. 1) opposes the conclusion that the specific structural difference above defined is merely one of degree of development and formation of the tooth. I shall, subsequently, note characters of another genus, which support the conclusion that degree of calcification of the coronal pulp may have been a specific, if not, also, generic character of some of these small fishes of the Carboniferous epoch.

The average size of the teeth of *Dittodus divergens* is 2 millimeters in length, $1\frac{1}{2}$ millimeter in basal breadth: the length of each crown is $1\frac{1}{3}$ millimeters, its basal breadth $\frac{1}{8}$ millimeter (Plate II., fig. 1, *a*).

The diameter of the trunks or pulp-ends of the dentinal tubes is $\frac{1}{8000}$th of an inch, rather more than half the average diameter of the same part of the tubules in human dentine. They have a

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more oblique course, inclining toward the apex of the crown, than in *D. parallelus*, and are fewer in number in a given space of dentine, both as being larger and also wider apart in such space. They soon branch, for the most part dichotomously, and are resolved into tubules of the minuteness and multiplicity of those in the dentine of *D. parallelus*, at about halfway toward the periphery of the crown (Plate II., fig. 2).

In the section figured (fig. 1), the pulp-cavity of one crown is obliterated by final conversion of the pulp into osteo-dentine (ib., *o*); in the other crown (*c*) a remnant of the cavity has been left. The osteo-dentine is characterized by large and irregular vascular canals or sinuses, and the calcified part is denser in texture than in that of *D. parallelus*. There is no trace in the osseous tissue preserved of radiated bone-cell; and the bone-tubes are in many parts obliterated, and seem to have been filled by amorphous bone-earth as a vital process.

I have not seen evidence weighing like that of the specimen (Plate I., fig. 1) in favour of the oral nature of the teeth of the present species of *Dittodus*; but the detached specimens testify in the minor degree, like those of *D. parallelus*, to their true character, by their irregular fractured base, and the absence of any defined supporting disc. Add the weight of analogy, and it may be warrantable to remark that the entire tooth of

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Dittodus divergens, both in shape and texture, was adapted for harder usage than in the first described species.

I may further remark, before quitting the notice of this singular, and, as far as my observations have extended, quite novel generic type of tooth, that it is paralleled by an occasional malformation in the human subject; viz., the confluence of two incisors. This abnormality is rare, and hitherto I have seen it only in the deciduous series;* moreover, the resemblance to the true twin-tooth is somewhat superficial; an entire tooth, both crown and fang, being united in the abnormal instances by co-ossification of the capsules, to a similar, more or less entire incisor, the base or root being actually double, as well as the crown.

* Since this was penned I have been shown, in the Museum of the Odontological Society, instances of such confluence in permanent teeth.

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Genus—MITRODUS,* Ow. (Mitre-tooth).

Species—*Mitrodus quadricornis*, Ow. (4-horned Mitre-tooth). Plate III.

The tendency to the development of distinct dentinal crowns from a common dental root or base, exemplified in the genus *Dittodus*, is exaggerated in other forms of extinct fishes of the Carboniferous period.

The tooth, of which the section is figured in Plate III., fig. 1, sends up four subequal conical crowns from the common osteo-dentinal base; and for this, since in some ancient forms of mitral diadems, the conical horns, or symbols of power, rose in two pairs, I have reserved the generic term *Mitrodus*, with the specific one of *quadricornis*.

The parietal dentine of each crown is continued into that of the contiguous one, and the dentine of the opposite sides of those at the two extremes of the series is extended some way down upon the osteo-dentinal base.

Each crown is shorter, broader at the base, more obtuse at the apex, than in *Dittodus divergens;* the longitudinal axes of the two middle crowns are parallel and vertical; those of the two lateral crowns are slightly divergent. As in

* μίτρα mitre, ὀδούς tooth.

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Dittodus divergens, the crown at one, probably anterior, end of the tooth is more completely calcified than that at the opposite end; and in the present series of four crowns, there is somewhat of a gradation in this respect.

That which I regard as at the anterior end (*m*) of the tooth, has the pulp-cavity obliterated by osteo-dentine, not more of the matrix remaining uncalcified than serves to exemplify the character of the medullary or vascular canal: in the next crown the apical part of the pulp-cavity remains (fig. 1, *b*, and fig. 2), its basal part is calcified: in the crown at the posterior side (*n*) the pulp-cavity is continued down into the common dental base, with partial interruptions of bone, to the subjacent supporting plate.

The structure of the dentine is less distinctly preserved in this than the preceding fossil teeth; but where it can be traced, it resembles in character that of *Dittodus divergens*.

The system of tubes continued and diverging from the medullary canal (fig. 3, *o*) in the tissue of the bone to which the base of the four-crowned tooth is anchylosed, strongly marks the piscine character of the fossil; but what appear to be cells, though sometimes plainly sections of medullary canals, are in greater proportion than in the bone of most existing species of osseous fishes.

The tooth of *Mitrodus* here figured is, in sec-

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tion, almost a square of $2\frac{1}{2}$ millimeters (fig. 1, *a*): the defined and expanded base (*e*, *e*) is in favour of its dermal character.

Genus—AGELEODUS,* Ow. (Herd-tooth).

Species—*Ageleodus Diadema*, Ow. (Crown Herd-tooth). Plate IV.

Whether any intermediate forms of multiplied crowns may have existed in the teeth, whether oral or dermal, of these ancient fishes, present materials have not shown; but in the tooth of which the section is figured in Plate IV., not fewer than a dozen subequal conical dentinal crowns are developed from a common osteo-dentinal base. Their size is less as their number is great; and both the proportion they bear to their common base, their shape, and arrangement on their slightly contracting support, at once suggests the resemblance of the tooth to the regal head-gear and symbol expressed by the specific term *diadema*.

I should have preferred for the generic term of the fish assumed to be characterized by the present form of tooth, *Botryodus*, or Cluster-tooth, from the aggregate arrangement of the many crowns; but that name has been bespoke;

* ἀγέλη herd, ὀδούς tooth.

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I have therefore taken the term *Ageleodus*, from the Greek for "herd."

With the augmented number of dentinal crowns, their thickness and expanse of base in proportion to height, has increased. One traces a gradation in this respect from *Dittodus* and *Mitrodus* to the present type. Most of the crowns are broader than they are high; all terminate obtusely; and this seems to be an original form, not due to wear or abrasion; for in some of the crowns a thin layer of ganoine seems to coat the summit of equal thickness with that on the side of the same crown.

There is also a gradation traceable in the direction of the tubules of the dentine from their transverse course in *Dittodus parallelus* to their vertical one in *Ageleodus*.

These tubuli have an average diameter of $\frac{1}{7500}$th of an inch, a little exceeding that in *Dittodus divergens*, but maintaining their size for a greater extent of their course, with an approach to a fasciculate arrangement, and resolving themselves into the minuter branches near the periphery (fig. 2, *d*), where some of them are continued into the clear ganoine (ib., *q*). The pulp-cavity is indicated by a depression at the base of the crown, nearly parallel with, but with a less degree of curve, than the peripheral contour of the crown. And this trace of pulp-cavity exists only in the larger cones at the mid-part of the

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tooth: towards the two extremes of the series in section, the dentinal crown rests by a flat base upon the osteo-dentine, and this substance completely fills the hollows indicating the remnants of the original pulp-cavities of the crowns. The dentine of the exterior sides of the two extreme crowns of the series is continued some way down the osteo-dentinal base, the upper half of which has thus been inclosed by the harder tooth-tissue, as in the less complete conditions of the present type of tooth exemplified by *Dittodus* and *Mitrodus*. The included and basally produced mass of osteo-dentine is characterized by larger medullary vacuities than in the previously described genera: the calcified portion is simply tubular, where any of the original texture can be discerned.

The sections of the medullary canals or cavities (ib., fig. 3) are mostly oval, less irregular than in the osteo-dentine of the previous genera. There is one feature in the part of the compound tooth which speaks for its essential individuality; viz., the remnant of the original common pulp-cavity (fig. 1).

I am aware that the characters which have just been described, as of the genus *Ageleodus*, may bear another interpretation. That which has been introduced as a single and characteristic tooth may be regarded as a pharyngeal bone supporting twelve or thirteen teeth or dental ridges. I think that

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if I had not seen and studied the dental characters of the species of *Mitrodus* and *Dittodus*, I should have been strongly disposed to adopt the view of *Ageleodus* being a pharyngeal dentigerous ossicle, and to have explained its characters according to the analogy of the pharyngeal bone of *Scarus*.* But here the difference would have been the imbedding of the dentine of the pharyngeal teeth in the substance of the bone in *Scarus*, also the evidence of the successional development of such teeth afforded by the degrees of abrasion at one end of the mass, and by the degrees of development of the teeth at the other end; together with the absence, in the recent fish, of that significant character in *Ageleodus*, of the investment, partial though it be, of the entire supporting bony base by the hard or unvascular dentinal tissue which composes the coronal divisions of the tooth. The contraction of this base to a somewhat irregular, as if broken, surface, combines with the character of the crown in leading me to regard the specimen (Plate IV.) as having come from some bone of the mouth.

I am moved, also, by another consideration in the course of description which I have adopted; viz., inasmuch as it is one best calculated to excite and facilitate comparisons of like ichthyic evidences from the other carboniferous localities or conterminous strata.

* "Odontography," plates 51 and 52.

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Viewing the specimen of *Ageleodus* as a single tooth, it resembles that of *Acanthurus* * among existing and, in section, that of *Ptychodus* * and *Ctenoptychius* among extinct genera.

In *Acanthurus* the divisions resembling the dentinal crowns in *Ageleodus* are obviously processes or crenations of the margin of the proper crown of the tooth, which is composed of a tissue more nearly approaching true dentine than the common basis of the tooth does in *Ageleodus*. The resemblance or analogy is closer in the large ridged crushing teeth of the extinct *Plagiostomous* genus. But, in *Ptychodus*, the osteo-dentinal basis of the tooth has a very different character from that in *Ageleodus*; the medullary canals having a more regular tubular form and arrangement, proceeding at right angles to the dentinal periphery, equidistant from each other, and occasionally bifurcating in their almost vertical course. In this basis, as in the true crown of the tooth of *Acanthurus*, there is no remnant of pulp-cavity in the fully-formed tooth, such as is shown by the specimen of *Ageleodus* here described. The medullary canals in *Ctenoptychius* have a general vertical and parallel course, but with more frequent lateral anastomoses than in *Ptychodus* and *Acrodus*. Agassiz† figures only a portion of a

* See magnified sections of these teeth in my "Odontography," plate 44, fig. 1, and plate 18.

† "Recherches sur les Poissons Fossiles," tom. iii., Tab. M, figs. 4 and 5.

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tooth of this genus, and describes the substance forming its base as being "parfaitement homogène." *

Moreover, the ridges, which, in a section of the grinding surface of the teeth of *Ptychodus* and *Ctenoptychius*, simulate the crowns of the tooth of *Ageleodus*, have distinct tubules of that extreme degree of minuteness which characterizes ganoine rather than dentine proper; and they do not show the two distinct substances which the crowns of the tooth of *Ageleodus* present. From this circumstance, therefore, as well as from the character of the osteo-dentine, and the remnant of pulp-cavity closed below, I infer that *Ageleodus* was not a member of the *Plagiostomous* order of fishes.†

* Tom. cit., p. 167.

† Any one possessing, as the critic (*loc. cit.*) must have been supposed by his readers to possess, microscopic sections of *Ageleodus*, would need only a glance at Tab. M., tom. iii., of the "Recherches sur les Poissons Fossiles," in which the structure of the tooth in *Ctenoptychius* is figured by Agassiz, to recognize the generic difference between it and *Ageleodus*. (October, 1867.)

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Genus—Ochlodus* Ow. (Crowd-tooth).

Species—*Ochlodus crassus*, Ow. (Thick crowd-tooth). Plate V.

Close-set as are crowns upon the base of the tooth of *Ageleodus*, or, as are the teeth themselves in parts of the dental series of the genus *Characodus*, they are more crowded in the fragment of bone figured in Plate V., which also exemplifies the difference between multiplied crowns of a single tooth and the aggregation of distinct teeth in a limited space. On the oral hypothesis, this alone, of all the sections of the jaws of the carboniferous fishlets which I have yet inspected, shows the character of disposition of teeth in two or more rows. The section seems to be one that has crossed the jaw from before *m*, backward to *n*; in which case it passes through an anterior row of smaller teeth, and a posterior row of larger ones, closely juxtaposed. Both teeth, moreover, show a distinctive character in the uniform thinness of the hard dentinal wall (ib., *d*), of an unusually large pulp-cavity (*p*, *p*). The teeth are short and broad cones, compared with the general form exhibited in most carboniferous specimens. They are recurved, acutely pointed, with the apex in the larger posterior tooth (*g*) gaining verticality

* ὄχλος crowd, ὀδούς tooth.

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by a slightly opposite bend. Only at a few parts of the section, as at *g*, *g*, can any trace of a distinct layer of ganoine be discerned, and this chiefly at the very sharp apex of the crown. The appearance of calcification of the pulp in the larger tooth I am disposed to interpret as part of the lateral parietal dentine (*d*, *d*), pressed in upon the matrix filling that cavity, in process of grinding down the section. It presents the character of hard dentine, and shows the tubuli in different degrees of oblique section. They are, however, from their extreme minuteness, and the unusual density of the tissue, but partially traceable. The histological character of osteo-dentine, which, as a rule, is the tissue into which the pulp of fish-teeth is converted, after the due proportion of parietal dentine has been formed, are certainly wanting in (*d*, *n*) Plate V.

The carbonated element of the matrix has invaded in unusual proportion the cavities at the widely open bases of these teeth, and precludes further extension of useful or reliable characterization of the fossil.

Of all the specimens of these coal fossils submitted to me, the subject of Plate V. was that which I, at first, was most disposed to refer to the genus *Diplodus*, the small intermediate cone being present, as in the type species of Agassiz. But besides the difference of size in the two teeth, *g* and *g'*, viewed in this comparison as the "lateral

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cones" of one tooth, there is the evidence of the non-continuity of dentinal tissue of the cone *m g* (Plate V.) with that of the cone *n g'*, or of either with that of the "median cone" of the unequivocal single tooth (dermal or oral) of *Diplodus*. Add to this the difference of structure as shown in the uniform thickness of the outer wall of hard dentine, to near the base of the crown, together with the minor degree of that thickness as compared with the width of the pulp-cavity.

I am unable, in the present instance, to adduce, as in the case of *Dittodus parallelus*, evidence to produce conviction or to sway the choice, as to the dermal or oral position of the above dental structure.

Sufficient, however, I believe to have been recorded for the main purpose aimed at in this paper; viz., to enable subsequent investigators to recognize the genus and species in teeth that may be discovered in the same or other localities.

The generic name has reference to the aggregate grouping of the three teeth in the present section; the specific name to the unusual thickness of the cone in the larger tooth. The length of this is 10 millimeters; the basal (fore and aft) breadth is 4 millimeters.

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Genus—GANACRODUS,* Ow.

Species—*Ganacrodus hastula*,† Ow. (Enamel-tipped spear-tooth). Plate VI.

Numerous specimens of detached teeth from the shale overlying the Low Main seam of coal at West Cramlington present the vague and ill-defined characters of those "en brosse" of *Palæoniscus* and *Amblypterus*, filamentary or graduating to a point: but there were others with the structure given in Plate VI., which arrested my attention with increasing interest as I proceeded with the examination, inasmuch as I had not before met with any similar structure in the whole range of my odontological researches.

The tooth of the type in question is long, slender, conical, slightly recurved, having about a fifth or sixth part of its length, at the apex, tipped or sheathed with a thick and well-defined layer of ganoine or fish-enamel (ib., figs. 1, 4, *g*), forming the sharp terminal point of the tooth, like the head of a pike or spear. This leading and conspicuous character is expressed by the generic term referring to the partial disposition of the enamel at the summit of the tooth; the specific name bears reference, also, to the analogy of this dental weapon of the carboniferous fish to a diminu-

* Gr. γάνος shine, ἄκρος point, ὀδούς tooth. † Lat., spearlet.

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tive spear (*hastula*). These teeth, of which I submit sections of three for examination,* are from three to four millimeters in length, and differ in degree of curvature between the two extremes (figs. 2 and 3, in Plate VI.). The basal diameter of the crown is not quite one-third the length of that part of the tooth: the breadth diminishes rapidly for a short way, then more gradually; the diameter of the crown at the mid-length being about half a millimeter. Near the enamelled tip the crown preserves its thickness, and then the dentine is abruptly cut away, as it were, to a narrow point, upon which the cap of ganoine is sheathed (ib., figs. 1 and 4, *g*).

The tooth has been fixed to the jaw by co-ossification of the base of the pulp, here converted into osteo-dentine (fig. 1, *o*), with the similar osseous tissue of the alveolar border. The long exserted crown consists of hard dentine (ib., *d*), like that in Sauroid fishes,† supporting the enamelled tip. The dentine quickly thins off from within outward and downward at the expanded base, and is gradually lost upon the exterior of the supporting mass of osteo-dentine (*o*). The pulp-cavity (fig. 1, *p*) resumes its area above the expanded part of the base, and retains it, gradually contracting to the apex of the dentine (except in

* These, with specimens of the other teeth described, were shown, under the microscope, to the meeting.

† "Odontography," plate 37 (*Rhizodus*).

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fig. 3, and here the appearance of obliteration may be possibly due to slight excentricity of the longitudinal section).

At the base of the crown above the osteo-dentine, the diameter of the pulp-cavity is nearly one-third the transverse diameter of the tooth at that part; the dentine, forming the other two-thirds, maintains its diameter more nearly, up to the enamelled head, the contraction of the crown being due, in greater degree, to that of the pulp-cavity, which at the apical third of the crown becomes a linear fissure.

The tubules of the dentine (ib., fig. 4, *d*) have a diameter of $\frac{1}{1000}$th of a line at their origin, and are resolved into more minute branches in a clear dense ganoid substance one-third of the way toward the periphery, and at the upper narrower part of the crown at one-half of the way thereto. The general direction of the dentinal tubules is transverse, or at right angles to the surface of the crown. At the base of the tooth the first short "primary curve" has its concavity base-ward, the rest of the tubule takes an opposite bend, but in a slighter degree: at the apical third of the crown, fig. 4, the first primary curve is obsolete, and the second one, concave point-ward, prevails to the terminal resolution of the trunk-tubules. The interspaces of these rarely exceed twice the diameter of the tubule. Throughout their course they are minutely, but somewhat

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irregularly and slightly, undulated, with occasional dichotomous divisions prior to resolution into the finest branches: they give off such ramuscules into the clear interspaces before terminal resolution. There is no definite exterior layer of ganoine or fish-enamel upon the dentine of the main body of the tooth (fig. 1, *d*), such as exists in *Palæoniscus*, Ag.; this tissue is restricted, as above mentioned, to form the spear-head. It is welded, as it were, into the kind of shallow circular groove at the apex of the dentine, and continues by quick acquisition of thickness the general contour of the coronal cone to the point, such contour being merely interrupted by the slight swelling at the co-adapted base of the enamel-cap with the dentinal groove.

In the tissue of the ganoine which shines conspicuously by transmitted light in contrasted clearness and lightness of tint with the darker dentine, very fine tubules or striæ may be discerned; some are seemingly in continuation with the apical tubuli of the dentine, and continue their direction, which tends more and more toward the apex, deviating gradually from the general more transverse course below the ganoine. The shape of the spear-head is after the model, or rather anticipates or affords the model, for the most efficient piercer. The contour, traced from the base, is at first convex, then for a greater extent concave, then again convex to the point;

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all the bends being very slight, and the whole forming the most gentle and graceful undulating outline of the converging sides, when seen in such vertical or longitudinal sections, as is figured in Plate VI.

From the teeth of *Megalichthys*, *Rhizodus*, *Holoptychius*, and the existing Sauroids, *Lepidosteus*, *Polypterus*, *Amia*, the dentine of *Ganacrodus* differs in the more definite modification of the central and peripheral halves, due to the speedier resolution of the trunk-tubules into terminal branches. The teeth of *Ganacrodus* differ also in the absence of the thin but well-defined layer of ganoine which covers the entire crown in the Sauroids cited, and is not partially or excessively thickened at the apex.

The peculiar armature of the long and slender teeth of *Ganacrodus*, the gradation of the thickness or diameter of crown, recalling the type on which the Lighthouse is constructed by such master-builders as Smeaton, the principle of strength associated with this form in the central vacuity of graduated or regulated area in reference to the due thickness of the solid walls;—all indicate a purpose or provision for piercing hard surfaces, such, *e. g.*, as the ganoid armour of coeval fishlets. One marvels in tracing out the several perfections of a spear-tooth on a scale so diminutive, and allotted for wounding at an epoch so remote. Truly, indeed, "for the variety, the beauty, the polish,

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the sharpness, the strength, the barbed perfection, the effectiveness in every way, of lethal weapons, no armoury can compete with that of the fossil world." *

Genus—GANOLODUS,† Ow.

Species—*Ganolodus Sicula*,‡ Ow. (Dagger enamelled tooth). Plate VII.

The teeth of which the structure is shown in Plate VII. offer those points of resemblance to the Sauroid type which are wanting in the previous genus; viz., a continuous covering of ganoine slightly and gradually thickened at the apex, and a more uniform character of texture in the coronal dentine, which is of the hard unvascular kind.

The teeth of this type are amongst the more common forms which Mr. Craggs has brought to light in his coal-sections.

They all have the crown of the more or less elongate, conical form, graduating to a sharp apex; less slender than the villiform teeth of *Amblypterus* and *Palæoniscus*, and much larger (Plate VII., *a*, nat. size) than the uniformly minute denticles in those genera. Of the teeth which I, therefore, refer to the genus *Ganolodus*, some are straight, or

* "Instances of the Power of God," &c. &c., 12mo, Longmans, 1864, p. 54.

† Gr. γάνος shine, ὅλος whole, ὀδούς tooth. ‡ Lat., dagger.

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almost straight (Plate VII., fig. 5); most are curved, a few rather strongly (ib., fig. 6); still fewer show a double curve, as in fig. 7: the more common type is that of fig. 1, and which I have expressed by the specific name *Sicula*, from the resemblance of the tooth to a "crease," or dagger.

The generic term expresses the total investment of the crown with the ganoine, or "fish-enamel." It forms a very thin layer; at the apex not exceeding, where thickest, $\frac{1}{10}$th of a line. The mode of attachment of the tooth to the jaw is the same as in *Ganacrodus*. The pulp-cavity remains unfilled by calcified substance above the attaching basal mass of osteo-dentine; and is continued, contracting, to near the apex of the tooth. The proportion of the cavity to the dentinal wall is always greater than in *Ganacrodus*, especially at the basal half of the crown. The dentine is similar in structure; the tubules rather finer at their origin, but continued much nearer to the periphery prior to resolution into the finest terminal branches, and also resolving into these more gradually. The primary curves, in the apical two-thirds of the crown, have a slight concavity toward the point from the origin of the tubuli: the general direction is less transverse than in *Ganacrodus*, a little more inclined point-ward; and this inclination becomes gradually greater toward the point. In a portion of the basal wall of the dentinal crown, cut through near the pulp-cavity (figs. 1 and 2, *b*), and pre-

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served, somewhat displaced in the slide figured, the dentinal tubuli show the undulatory primary curves, as in the basal part of *Ganacrodus;* viz., with a short point-ward convexity before the more general concavity is taken. Dark specks, like cells, are scattered about some parts of the dentine; but have no relation, I believe, to original structure.

One of the teeth of *Ganolodus*, figured in Plate VII., *a*, of the natural size, shows a length of a crown of 9 millimeters, and a basal breadth of 4 millimeters.

Of the better preserved evidences of mandible in the lower coal-shales of Northumberland, some illustrate and confirm the dental character ascribed by Agassiz to his genera *Palæoniscus* and *Amblypterus*.* Others, by an abrupt increase of size and length in single teeth of the dental series indicate a species of *Pygopterus;* but I have not

Fig. 2.

Mandible and teeth of *Ganolodus Craggesii*. Natural size.

hitherto met with a specimen of the jaw of that genus, or of *Platysomus*, or *Eurynotus*, which shows the larger laniary tooth taking the lead of

* "Les dents sont si excessivement petites qu'il est très rare de pouvoir les distinguer; elles sont en brosse."—"Recherches sur les Poissons Fossiles," 4to., tom. ii., p. 42.

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the series of small, fine, conical tooth, as in the subject of the cut (fig. 2). It is from jaws so characterized that teeth of my genus *Ganolodus* have been derived.

Genus—MIOGANODUS,* Ow.

Species—*Mioganodus laniarius*, Ow. (Laniary less-enamelled tooth). Plate VIII.

The tooth, of which the section is figured in Plate VIII., resembles an incompletely formed canine of a young mammalian carnivore, save that the enamel of the crown is not present in mammalian proportions and structure, and, further, that the dentine is of that extremely dense character, through a minuteness of tubules, for the like of which we must descend to the class of Fishes, as, *e. g.*, in *Diodon*,† *Microdus*,‡ and *Labrus*.§ The ganoine is only discernible as an extremely thin layer upon that apical part of the crown (Plate VIII., *b*, *c*) which simulates the whole crown in the mammalian canine; and this minor proportion of the lustrous tissue, as compared with *Ganolodus*, suggested the generic term under which the present form of tooth is introduced to the notice of the Society.

* μείων less, γάνος shine, ὀδούς tooth.
† "Odontography," plate 39.
‡ Ib., plate 43. § Ib., plate 46.

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I believe it to be wholly the coronal part of an undeveloped tooth; with a widely-open pulp-cavity, and an absence of any conversion of the pulp, or connection of the hard coronal dentine, with osteo-dentinal tissue. But in this incomplete state the present tooth offers what I view as a generic distinction from *Ganolodus*, in the obliteration of the pulp-cavity, by dentinal conversion, throughout that apical third part of the existing crown (fig. 1, *b*, *c*) which I have compared to the crown of the mammalian canine.

In the superinduction of defined shape upon the simple graduated cone which permits a definition of such part of the crown, and in the degree of obtuseness and apical thickness of a tooth not blunted by use, I find myself compelled to appreciate characters differentiating such tooth from the common crowd of villiform teeth in these coal-shales that may be vaguely referred to *Palæoniscus* or *Amblypterus*.

The dentinal tubuli have a general course at right angles to the periphery of the crown, graduating from the transverse to the vertical direction which they assume in passing to the apex; with slight and simple but elegant primary curves, gently curving point-ward in leaving the pulp-cavity, and changed for an opposite curve in approaching the periphery. In the solid part of the crown the primary curve, convex point-ward, is stronger on the anterior half (*m*) of the

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dentine, and is scarcely, if at all, changed in reaching the surface. In the posterior half such curve is less marked, and the course of the main tubules retains the wavy character. The size of the tubuli does not exceed a diameter of $\frac{1}{880}$th of a line: they are for the most part unbranched. It is most difficult, at least, to detect any branch of division or resolution even at their peripheral ending. The concentric lines or layers of the clear structureless calcified basis, parallel to the contour of the crown, and at right angles to the course of the dentinal tubules, is better marked at the apex (Plate VIII., fig. 2) of this than of any other tooth in the present series. It is a character extremely rare in teeth of existing fishes (Sauroids, *e. g.*) of a similar hard dentinal type.

The tooth here described is larger than the majority of such fossils in the present series. It presents a length of 10 millimeters, with a basal breadth of $3\frac{1}{2}$ millimeters.

Genus—AGANODUS,* Ow.

Species—*Aganodus apicalis*, Ow. (Apical unenamelled tooth). Plate IX.

The first of the specimens now referred to the present genus, which I examined, suggested the

* *α* priv., *γάνος* shine, *ὀδούς* tooth.

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idea that the covering of enamel had been accidentally displaced from the dentine in the preparation of the section. But the same absence of enamel was repeated in other sections, to all appearance made with the same care and success as the slides of *Ganolodus*. I next observed that a different disposition of the dentinal tubules prevailed in this unenamelled type of tooth from that in *Ganolodus*, and that also in teeth of different forms; and I ultimately concluded that the most useful line of treatment would be to propose the new modification as a character of a distinct genus, with suitable illustrations, so as to afford a subject of comparison of a definite kind to future investigators of the dental evidences of the small fishes in other carboniferous localities.

The present species has the tooth prolonged from a relatively broader basis than in the two preceding genera, into an unusually long and slender crown. The contraction is rapid above the base, and then gradual in the upper two-thirds. The apex is obtuse, and, from the obliteration of the pulp-cavity, I believe to be entire. The pulp-cavity is unusually expanded above the attaching mass of osteo-dentine, but more rapidly contracts than the crown itself, and is continued slender, and still contracting, to within one-sixth the length of the crown from the apex. The osteo-dentine into which the base of

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the pulp has been converted approaches the character of hard dentine by the great proportion of the finely tubular calcified part as compared with the medullary canals. The section of some of these canals presents the appearance of radiate cells, under a magnifying power of 100 diameters (Plate IX., fig. 3, and Plate X., fig. 3). It forms, however, but a thin layer or flooring for the base of the tooth, beneath which the ordinary bone-structure of the fish-jaw is resumed.

The dentine constituting the entire crown of the tooth is traversed by tubules with an initial diameter of $\frac{1}{250}$th of a line, and characterized by the number and strength of their primary curves; their general direction being obliquely outward and upward. They give off branches at an acute angle from their commencement, and are gradually resolved into the finest ramuli near the periphery. In some parts of the section the dentinal tubules presents a fasciculate arrangement, somewhat resembling the modification of fish-dentine in *Lepidotus*,* but with wider intervals between the tubules.

The foregoing description of the shape of the tooth must be received with the reserve that the longitudinal section described may be transverse to the supporting bone, not from before backward; but the main character, repeated in the following sections, would not be affected thereby.

* "Odontography," plate 31.

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Species — *Aganodus undatus*, Ow. (Wavy unenamelled tooth). Plate X.

In the specimen representing this species (Plate X.), calcification has made further advance than in the subject of Plate IX. The basal platform of osteo-dentine (Plate X., fig. 1, *b*) is extended in a conical form upward into the pulp-cavity (ib., *p*); but the outspreading character of the base of this cavity is still shown, its extension being greater in the posterior direction (Plate X., fig. 1, *n*; ib., Plate IX., *n* ?). The proportion of the dentinal walls to the persistent pulp-cavity in the crown of the tooth is greater; and the shape of the tooth differs from that of *Aganodus apicalis*, in a degree which moves me to present it under a distinct specific name.

The entire crown has a general curve backward, but with an apical bend toward verticality, and a strong sigmoid or wavy contour of the posterior border of the section, due to a ventricose thickening or bulging of the dentine at the basal third of that part of the crown; the strong convex contour of the section passing into a concave curve before terminating in the slighter convex line leading to the apex. The crown is constricted above the basal platform before developing the above expansion. The dentine presents a generic conformity of character with that of the

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foregoing species, but with the above-noted modifications of form, which, with present materials, may be held as specific.*

Genus—Pternodus,† Ow.

Species—*Pternodus productus*, Ow. (Drawn-out heel-tooth). Plate XI.

Some of the small teeth with crowns of unvascular dentine, uncoated by ganoine, have the hinder part of the base (Plate XI., fig. 1, *n*) drawn out like a heel. They differ, moreover,

* The critic of the published "Abstract" of this Paper, writing under the name of Thomas Atthey, would have it believed that the characters of *Ganacrodus*, *Ganolodus*, *Mioganodus*, and *Aganodus* (Plates VI.—X.), "depend entirely on the plane of the section." "The apparent extent and form of the enamel-tip also," he affirms, "varies much in accordance with the section. Some specimens are entirely coated with a thin film of enamel; in others, traces of it only can be observed; and in some again, it seems entirely wanting, owing, apparently, to the state of preservation of the specimen." (*Geological Mag.*, August, 1867, p. 380). Had Mr. Atthey made known these differences of structure prior to my researches and their communication to the Odontological Society, in June, 1867, I should have acknowledged such help with pleasure; but I could not have admitted the mechanical and accidental cause assigned. It is truly inconceivable that any one who had seen a section of *Ganacrodus* could suppose such a tooth to be transmutable by any sleight of section or manipulation into *Ganolodus*, &c. Similarly, if we accept the dental characters assigned by the founder of Palichthyology to his genera *Palæoniscus*, or *Amblypterus*, we cannot refer thereto, without darkening knowledge, the teeth figured in Plates VI.—VIII.; especially when recognisable teeth of both these "genera occur in the shale connected with the Low Main." —October, 1867, R.O.

† Gr. πτέρνα heel, ὀδούς tooth.

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from the type *Aganodi*, as well as from the teeth of *Palæoniscus*, *Platysomus*, and *Pygopterus*, in a more gradual basal expanse of the pulp-cavity, and in the absence of the thin platform of hard osteo-dentine which supports in them the crown of the tooth and divides it from the ordinary bone of the jaw. I therefore take this as ground for a generic distinction, and introduce my eleventh form of carboniferous fishlet tooth under the name *Pternodus*, or "heel-tooth," with the specific term *productus*.

The specimen figured is an old or well-calcified one. A linear remnant of pulp-cavity extends from the apex of the conical expansion along the middle third of the dentinal crown, and is obliterated in the apical third. All the cavity below is occupied by a mass of osteo-dentine, ib., *o*, continuous with the bone of the jaw, which overlaps the heel-like production of the hind part of the base of the dentinal crown. The dentine itself corresponds in character with that of *Aganodus undatus*. Fig. 2 in Plate XI. shows the change in direction of the dentinal tubules as they approach the apex of the crown.

In the bony or osteo-dentinal base (fig. 1, *b*), the tubular structure in longitudinal tracts, which the tubules (fig. 3, *d*) traverse transversely, marks the class to which the present genus and species belong.

The length of the specimen figured (fig. 1, *a*) is

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7 millimeters, in a straight line from the point to the end of the heel, *n*; the breadth of the base is 5 millimeters.*

Genus—Sagenodus,† Ow.

Species—*Sagenodus inæqualis*, Ow. (Different-sized Seine-tooth). Plate XII.

The teeth in the small portion of jaw figured in Plate XII. offer a type of structure akin to that in the extinct *Dictyodus*‡ and the existing *Sphyræna*,§ appearing to be mere or direct tooth-like processes of the jaw, of which they continue the structure with little modification. In the present carboniferous fossil they do not even superadd the filmy coating of ganoine which may be seen in the teeth of the eocene *Dictyodus*; but they do differ from the supporting jawbone in the more regular and elegant reticulate disposition of the medullary canals (ib., figs. 1 and 2).

The six teeth or tooth-like processes in the section described and figured (ib., fig. 1, *b*, *c*, *d*, *e*, *f*, *g*), present a graduated difference of size from one

* A section of part of a *Diplodus* may, no doubt, be made so as to give it "a heeled appearance" ("Geol. Mag.," *l. c.* p. 380); but the structure of *Pternodus* is as distinct from that of *Diplodus* as it is from that of *Dittodus*, and each is equally distinct from the other.—Oct. 1867, R. O.

† σαγήνη seine, ὀδούς tooth.

‡ "Odontography," plate 54.

§ Ib., plate 53.

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end of the alveolar series to the other; the largest (ib., *b*) being, probably, the foremost in position. They are all in the form of simple cones; but the summit becomes more obtuse as they decrease in size. The length of the specimen is 6 millimeters: that of the first or longest tooth is 2 millimeters, including the subjacent portion of jaw, in parts of which the large medullary canals assume a more parallel course. It is quite possible that the section offering the appearances above described may have traversed obliquely and inequally the bases of more perfect teeth. In that case, however, the structure preserved is so well marked, that I offer the description and name with a view to help the recognition of other and more complete specimens of the species.

Genus—CHARACODUS,* Ow. (Stake-tooth).

Species—*Characodus confertus*, Ow. (Close-set Stake-tooth). Plate XIII.

In the longer portion of dentary bone, selected for the subject of Plate XIII., fig. 1 and *a*, a greater number of more equal-sized vertical processes of the alveolar border of the jaw, with a more dictyodont type of structure than that of the subjacent bone, are arranged in close-set series; and I

* χάραξ a stake, ὀδούς tooth.

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derive from the less developed state of these processes assurance, which I did not feel when I first examined, and only knew, *Sagenodus inæqualis*, that they do represent, or are homologous with, the histologically more differentiated teeth in other fossil, and in recent fishes, or, at least, their basal portions.

The pulp-cavity, though closed by the bone at the bottom, remains widely open in the body of the anterior tooth (Plate XIII., fig. 2, *b*, *p*). From the small proportion of osteo-dentinal substance above the pulp-cavity, one is disposed to conclude that much of the proper crown of the tooth has been worn or broken away. From the common level at which all the succeeding teeth stand, it would appear to be due to natural attrition rather than to any accidental violence. But, whatever be the actual state of the case, the appearances presented by this undoubted dentigerous portion of jaw are so strange and well-defined, that they cannot fail to be recognized, if found repeated in other coal fossils, after comparison with the descriptions and figures here given.

As in *Sagenodus inæqualis*, the teeth decrease in size from the fore (*m*) to the hind (*n*) part of the alveolar series; but they are much more numerous, and the diminution is more gradual. I make out about twenty-eight teeth in the portion of the dentigerous bone preserved (ib., fig. 1, *a*).

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In the foremost and largest tooth (*b*) the pulp-cavity (*p*) is inclosed at every part, save its roof, with osteo-dentine, partaking, in the large size of the medullary canals, of the character of that in most of the previous specimens, and directly continuous with the subjacent bone. The roof of the cavity is formed by a denser tissue of the structure of dentine. In this part of the tooth (fig. 3, *d*), the tubules present a diameter of $\frac{1}{12,000}$th of an inch, with intervals of three or four of those diameters. Their course is divergent, and, short as it is in the small portion of the tissue preserved, it indicates the usual tendency to verticality to the outer surface of the crown. After the fifth tooth, as many follow, so closely packed together in longitudinal series (ib., fig. 1, *c*) that they seem to be confluent at their osteo-dentinal bases, above the pulp-cavity, in the present section. Beyond these the teeth get a little more apart, become more minute, and seemingly more simple; for it is not satisfactorily determinable whether *e*, *f*, *g*, fig. 1, are pairs of distinct and simple denticles, or the opposite side-walls of larger teeth worn or broken away across the pulp-cavity.

Howsoever this may prove, the characters of the present specimens, as before remarked, are sufficiently distinct and peculiar to lead to the determination of fossils showing the same kind of jaw and teeth, and thereby help to extend and

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rectify the notions of the characters deducible from the present section.

From the contrast in the vertical diameters of the portion of jaw at *m* and *n*, some may think that the more attenuated end should be the anterior one; but I am more swayed by the analogy of the usual form of the dentary piece in the piscine and batrachian mandible, in which, with a vertical anterior extent corresponding with that of the symphysis, to the degree in which the depth of that joint may be characteristic of the jaw, the dentary gradually diminishes in such diameter to a point as it recedes backward to overlap in its squamous junction with the articular element. In one part of the bone the structure is so far preserved as to show bone-cells in longitudinal section (fig. 3, *r*), of $\frac{1}{600}$th of an inch in length, resembling in shape and the number of canals, and their mode of divergence, those of the frog, and the specimen may be part of a small batrachian.

The length of the portion of jaw in the section prepared (Plate XIII., fig. 1, *a*), is 15 millimeters; the vertical diameter anteriorly is 3 millimeters. As the section offers the appearance of a hedge of stakes, the name *Characodus*, stake-tooth, suggested itself, as a sign of this modification of dental structure.

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Genus—Gastrodus,* Ow.

Species—*Gastrodus præpositus*, Ow. (Leading belly-tooth). Plates XIV. and XV.

Of this genus I have sections of two portions of dentigerous jaw, and of detached teeth. All the most complete teeth *in situ*, and the detached specimens (Plate XV., figs. 4 and 6), show a large pulp-cavity inclosed by a thin wall of unvascular dentine, and in no case does any tissue like osteo-dentine encroach upon the pulp-cavity. In this respect the teeth resemble those of *Dendrerpeton* and the frog, and differ from the teeth of most fishes. The tissue of the dentine, as well as that of the jawbone, bears the same resemblance to those in the *Batrachia* cited.

The portion of jaw (Plate XIV., fig. 1, *a*) is 14 millimeters in length, and supports at least twenty teeth, separated by intervals about equal to their basal diameter, except as regards that between the largest, which I take to be the foremost, tooth (*b*) and the next.

All the teeth are conical and obtuse; the first being twice the length and thrice the breadth of the average of the succeeding teeth. These gradually diminish in length or height to the end

* γαστήρ belly, ὀδούς tooth.

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of the series; and where the gradation seems to be broken, as at *e*—*h*, it arises, as may be seen by microscopic examination of the dentine, from the excentricity of the section, either by removing a great part of the pulp-cavity, and showing the texture of the further wall, as in tooth, Plate XIV., fig. 4, or by removing more or less of the crown itself, as in the teeth, ib., fig. 1, *e*, *f*, *g*.

The dentine manifests all the typical characters of that tissue as shown in existing *Batrachia*. The dentinal tubules have a diameter of $\frac{1}{10.000}$th of an inch, with intervals of from three to four of their diameters. Throughout three-fourths of the crown, from the base, they present, as in fig. 3, Plate XIV., a primary curve gently concave pointward, extending to within one-fourth of the periphery of the dentine, when the direction of the branches they there resolve into affects the opposite curve: their general direction is outward, and a little upward, changing gradually, when near the apex, to the vertical position; but some of the tubuli near the apex make a strong and short curve, concave pointward, and are then continued vertically; thus departing from the general graduated arrangement. At the base of the crown of the larger anterior tooth are portions of the lateral wall, which have been ground down in a direction across the line of the tubules, and these sections show the "lumina" or cavities and walls of the tubules, and the proportion of the

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intervening clear, hard, or calcified substance, as at fig. 3, *t*, *t*.

In the section of the parietal dentine in fig. 4, an instructive gradation of sections of the tubules from the direct cross-cut, to one lengthwise, as at the apex, is demonstrated.

Each tooth is attached to a low process of the alveolar border, which is hollow or cylindrical, with the dentinal base of the tooth inserted into the mouth of the cylinder; and the dentine is thinned off as it descends, adhering to the inner surface of the process, as shown in figs. 2, 5, 6, 7, Plate XIV. There is no gradual change from the dentinal to the osteo-dentinal tissues here. The primitive matrix of each tooth has been more definitely developed, *i. e.*, more distinctly, from the formative cartilage of the bone; and both have been calcified according to their special laws or patterns, until the anchylosis followed the contact of the dentine with the supporting bone.

In Plate XV. two of the sections of detached teeth of this hollow dentinal batrachian type, which I refer to the same species of *Gastrodus*, are figured (figs. 4, 6).

The osseous tissue shows plainly the medullary or Haversian canals, the laminæ, and the intervening lacunæ, or bone-cells, with their radiating tubuli; all in proportion and pattern according to the batrachian type, and herein very

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closely resembling that in the *Parabatrachus* of the Carluke coal, and the *Dendrerpetons* of the Nova Scotia coal-fields.

As the medullary canals are more curved and irregular at and near the alveolar part of the jaw-section, the laminæ partake of such character, and the bone-cells are arranged along similar irregular curved lines: here the bone-cells show a long diameter of $\frac{1}{500}$th of an inch, a short diameter of about $\frac{1}{600}$th of an inch.

In the lower part of the jaw the medullary canals are chiefly longitudinal, and the bone-cells lie with their long axes therewith parallel, as at B, *b*, fig. 1, Plate XV. At the part of the jaw-section (Plate XIV., fig. 1, *o*), the bone-laminæ alternate with medullary canals or vacuities, of similar or greater vertical extent, both affecting the longitudinal course: some of the laminæ have not more vertical thickness than suffices for a single bone-cell, or two. In these lamellæ the line of section through the bone-cells shows their flattened sides to be parallel with the periphery of the longitudinal canal, and their longer diameter is in the direction of the length of the canal: their shorter diameter is less than in the bone-cells exposed by the more oblique sections of the more irregular alveolar canals; for whilst the long diameter of the lower or longitudinal bone-cells may be $\frac{1}{400}$th of an inch, the short diameter is frequently $\frac{1}{800}$th of an inch: but in no instance do the bone-cells

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present that extreme length which characterizes them in the recent and extinct Sauroid fishes.

From the foregoing particulars of structure I infer that we have in *Gastrodus* evidence of a minute air-breathing batrachian, of the age of the lower seams of the Northumberland coal-field.

If this inference be a true one, and should receive confirmation from subsequent discoveries, it may weigh in forming an opinion of the nature of the medium in which some of the more minute fishes—of the size of the stickleback or minnow—lived, which have yielded so many new, curious, and beautiful modifications of dental structure; but, on the other hand, rises the obvious suggestion that remains of the air-breathers may have been carried sea-ward along with the débris of the vegetation amidst which they lived, and that such deposit may have received in some estuary, or further out at sea, the remains of sea-fishes.

With regard to the array of generic and specific names, under which have been recorded the present series of observations, I can offer no disproof to the objection that a *Mitrodus* (*e. g.*) may have come from another part or bone of the same fish as yielded the *Dittodus* type of teeth; and if analogy should leave the balance of probability in favour of my interpretation, the objectors might fall back upon the closer resemblance of the two teeth introduced, as types of

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the two species of *Dittodus*, viz., *parallelus* and *divergens;* and so also, in regard to the here called species of *Ganolodus*, *Aganodus*, &c.

There is a choice of doubts or difficulties in all such cases of initial observation of novel series of facts. I have been moved, in the alternative taken, by the condition of affording most facility in the making and expressing comparisons to those who may follow me in this line of research: of the determination, viz., of the kinds and sorts of *Hæmatocrya*, or cold-blooded vertebrate animals, that have left remains for the anatomical interpreter, in strata so interesting on account of their vast geological age as the Carboniferous period.

For present materials in aid of such researches I have already expressed my deep indebtedness to Mr. Craggs, from whom alone I have, hitherto, been favoured with sections of coal-fossils. But I am aware that industry and skill, like his, have been devoted to a like object by a few other residents in the coal districts, and more especially by Mr. Thomas Atthey, whose name deserves honourable mention in connection with the preparation of sections like these described in the present paper.*

* In the paper by J. W. Kirkby and Thomas Atthey, in "Transactions of the Tyne-side Naturalist's Field Club," vol. vi., part ii. (1864), p. 231, the fish-remains at that date known to those authors are referred by them, "assisted by Sir t hilip de Grey Egerton, in their determination" (p. 233), to the genera *Rhizodus*, sp. *lanciformis* (Plate VI., figs. 1, 3), *Holoptychius*, sp. *sauroides*, Plate VI., figs. 4—6 and

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In conclusion, I have pleasure in expressing my obligations to Mr. Tuffen West for the kind and ready manner in which he put all his time at my disposal, when I first showed him my selection of sections of carboniferous teeth and bones, and made known my wishes respecting them: to the fulfilment of these is due what I feel to be the most valuable part of the present paper, viz., the accurate and beautiful plates with which it is illustrated.

to undetermined species of the following genera:—*Megalichthys*, *Pleuracanthus*, *Orthacanthus*, *Gyracanthus*, *Ctenoptychius*, *Diplodus*, *Ceratodus*, *Platysomus*, *Cœlacanthus*, *Paleoniscus*, and *Acrolepis* (?): the paper contains no reference to any microscopic evidences of species, or to the procedures by which such can be prepared for investigation.

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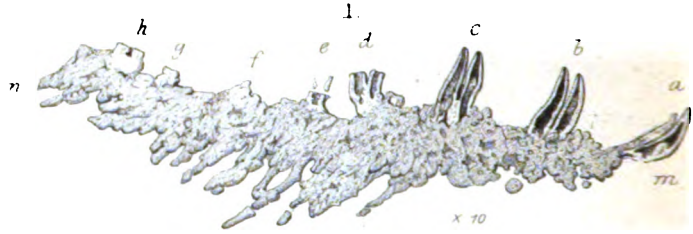

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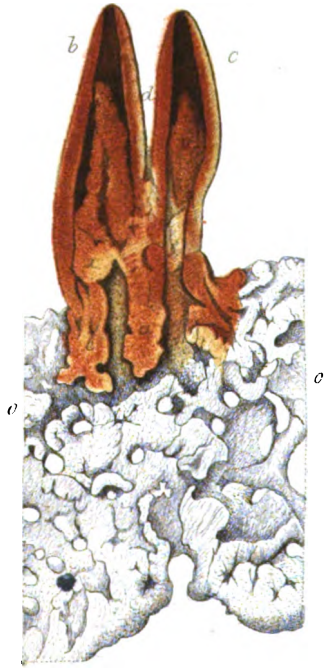

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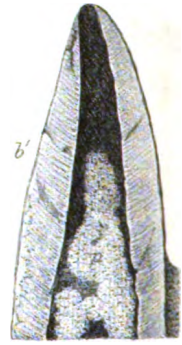

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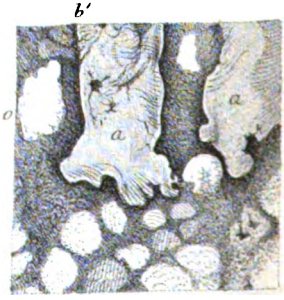

Turin Mus. del. & sc.

Wilkes chromo.

DITTOCUS PARALLELUS

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PLATE I.

Dittodus parallelus.

Fig. 1.—Portion of (probably dentary jaw-) bone with teeth, in longitudinal section, magnified 10 diameters: *m*, fore end, *n*, hind end; *a*, *b*, *c*, *d*, twin-teeth; *e*, *f*, *g*, *h*, alveolar processes with confluent base of teeth.

Fig. 1*a*.—Ib., nat. size.

Fig. 2.—The twin-tooth (*c*, fig. 1), in longitudinal section, magnified 50 diameters: *a*, common base; *b*, posterior crown; *c*, anterior crown; *o*, osteo-dentinal base of tooth and part of confluent bone.

Fig. 3.—Posterior crown and corresponding part of base of the twin-tooth (*c*, fig. 1), in longitudinal section, magnified 100 diameters: *b'*, dentinal wall of crown, showing course of tubules; *p*, osteo-dentine in apical part of pulp-cavity; *a*, *a*, osteo-dentinal base of tooth, with remains of the pulp-cavity; *d*, osseous tissue of supporting bone.

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PLATE II.

Dittodus divergens.

Fig. 1.—Twin-tooth, in longitudinal section, magnified 50 diameters: *a*, nat. size; *b*, anterior crown; *c*, posterior crown; *o*, osteo-dentine of pulp-cavity; *d*, common osteo-dentinal base.

Fig. 2.—Portion of crown, *c*, in longitudinal section, magnified 100 diameters; showing course and ramifications of dentinal tubules.

Fig. 3.—Portion of the common osteo-dentinal base at *d*, fig. 1, showing continuation of the canals, with dentinal tubules at the basal termination of the anterior wall of dentine.

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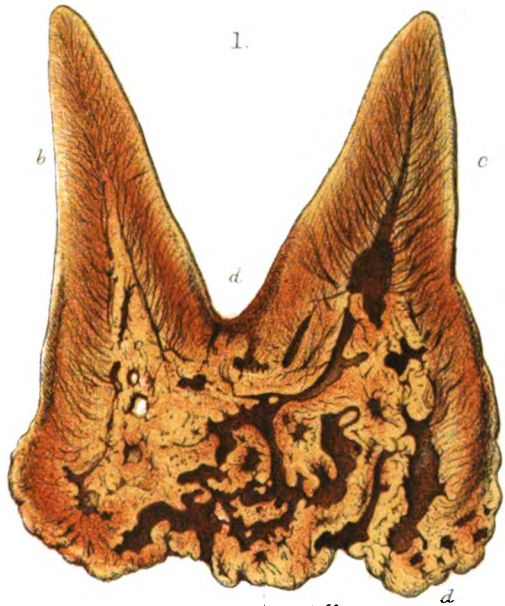

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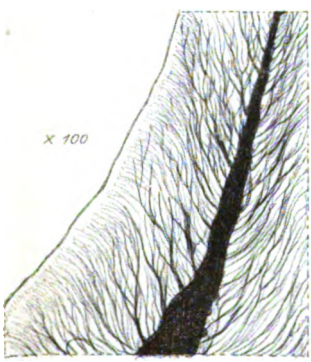

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W.West. Chromo Lith.

DITTODUS DIVERGENS

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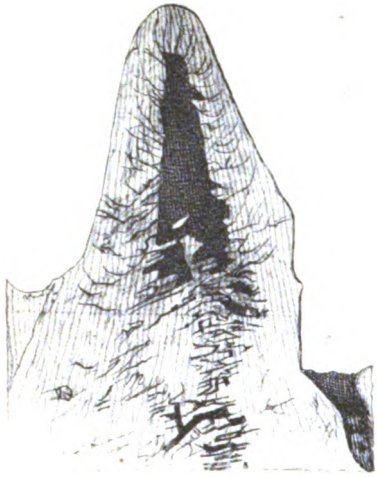

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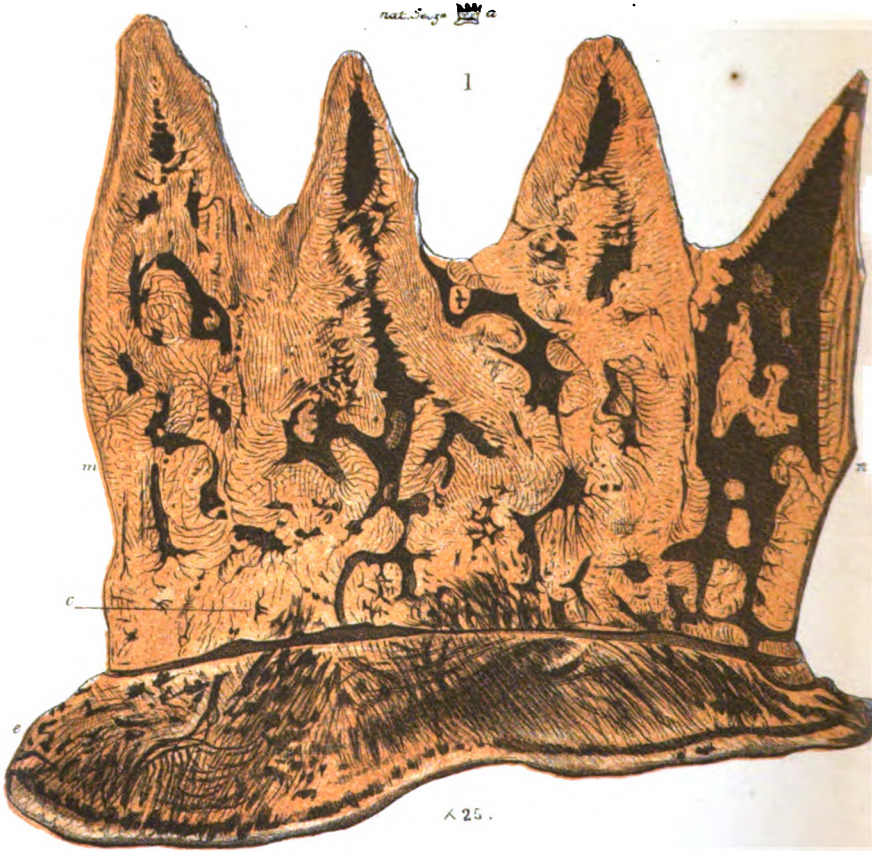

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T.West del.
Stone by J. Erxleben

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MEROPIDÆ. MEROPS.

PLATE III.

Mitrodus quadricornis.

Fig. 1.—Tooth in longitudinal section, magnified 20 diameters: *a*, nat. size.

Fig. 2.—Longitudinal section of third crown, magnified 50 diameters.

Fig. 3.—Portion of supporting osseous disc, magnified 50 diameters.

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PLATE IV.

Ageleodus Diadema.

Fig. 1.—Tooth, in longitudinal section, magnified 20 diameters : *a*, nat. size.

Fig. 2.—Longitudinal section of one of the crowns, with part of subjacent osteo-dentine, magnified 50 diameters.

Fig. 3.—Part of the osseous base, magnified 50 diameters.

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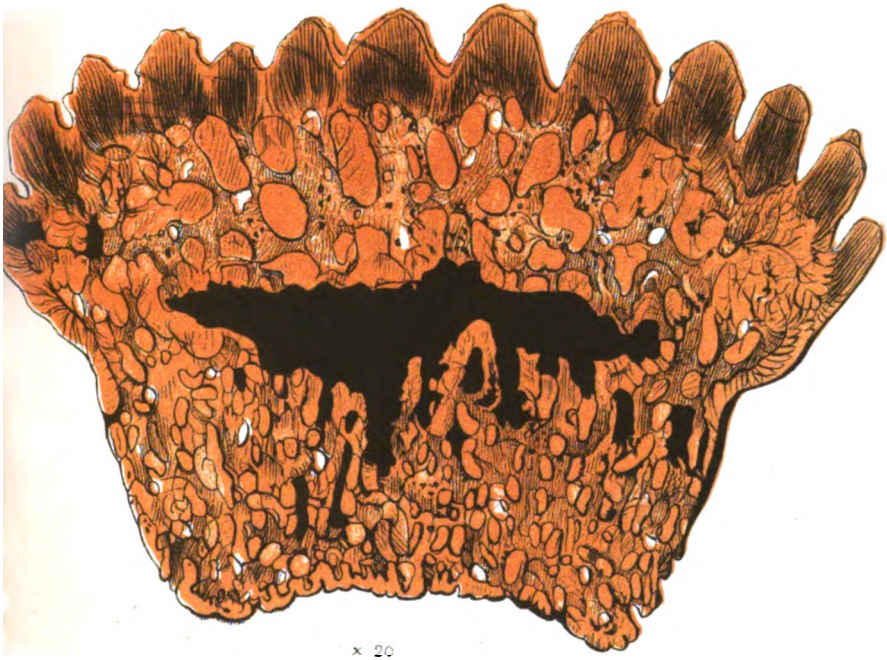

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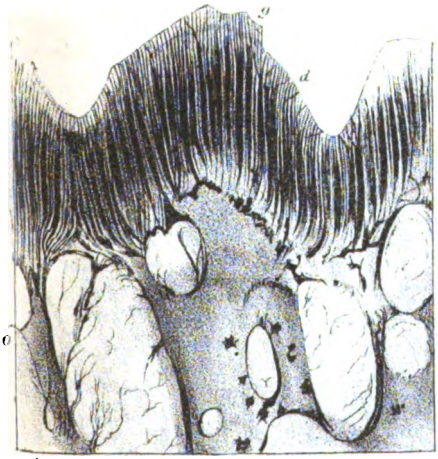

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F.West del. et lith. Ernakulam

AGELEODUS DIADEMA

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Fairholme West del. & sc.

W.West Chromo-litg.

OCHLOEUS CRASSUS

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PLATE V.

Ochlodus crassus.

Group of three (dermal?) teeth, in longitudinal section, magnified 17 diameters: *a*, nat. size; *d*, dentine; *g*, ganoine; *p*, pulp-cavity; *m*, fore, *n*, hind part of section.

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PLATE VI.

Ganacrodus Hastula.

Fig. 1.—A tooth, in longitudinal section, magnified 50 diameters: *a*, nat. size; *d*, dentine; *g*, ganoine; *o*, osteo-dentinal base confluent with the osseous tissue of the jaw; *p*, pulp-cavity of tooth.

Fig. 2.—A tooth, in longitudinal section, magnified 15 diameters; more bent than in fig. 1.

Fig. 3.—A tooth, in longitudinal section, magnified 15 diameters; less bent than in fig. 1, and of smaller size.

Fig. 4.—Enamelled summit and part of subjacent dentinal wall of a second tooth, magnified 100 diameters: *d*, dentine; *g*, ganoine.

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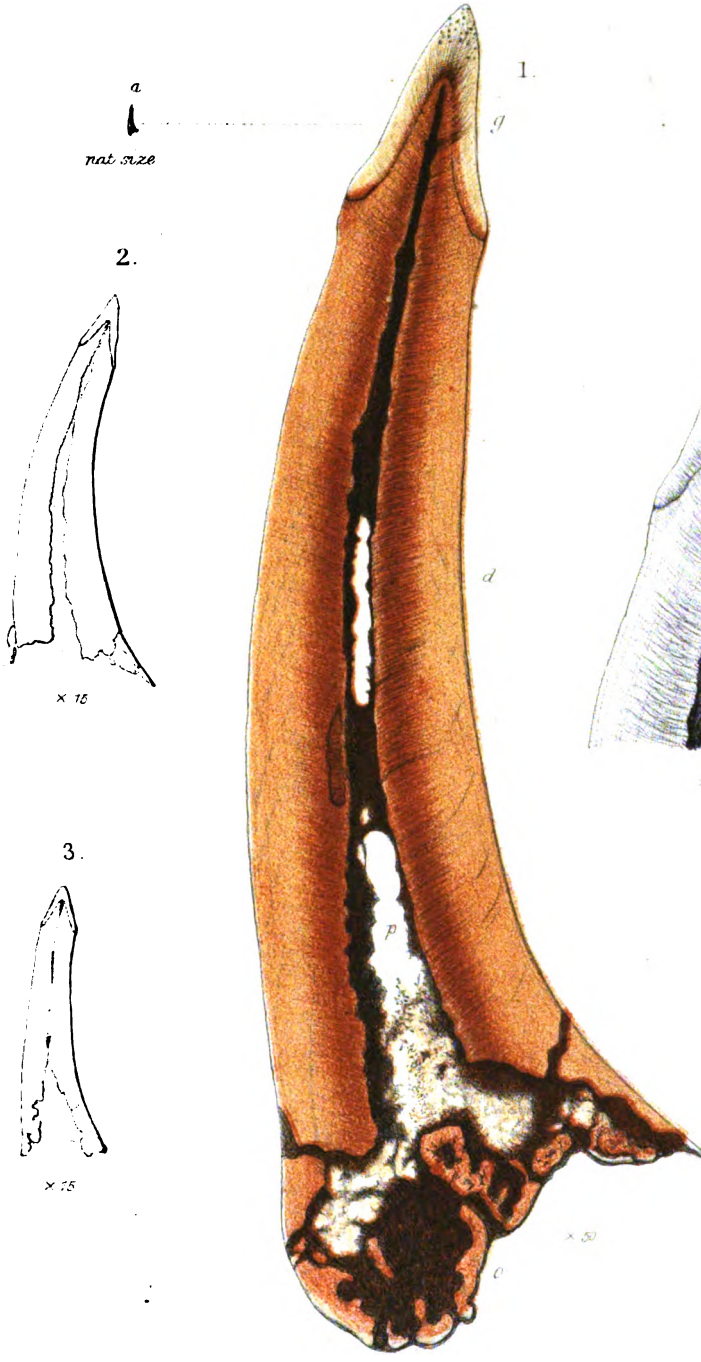

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GANACRODUS HASTULA.

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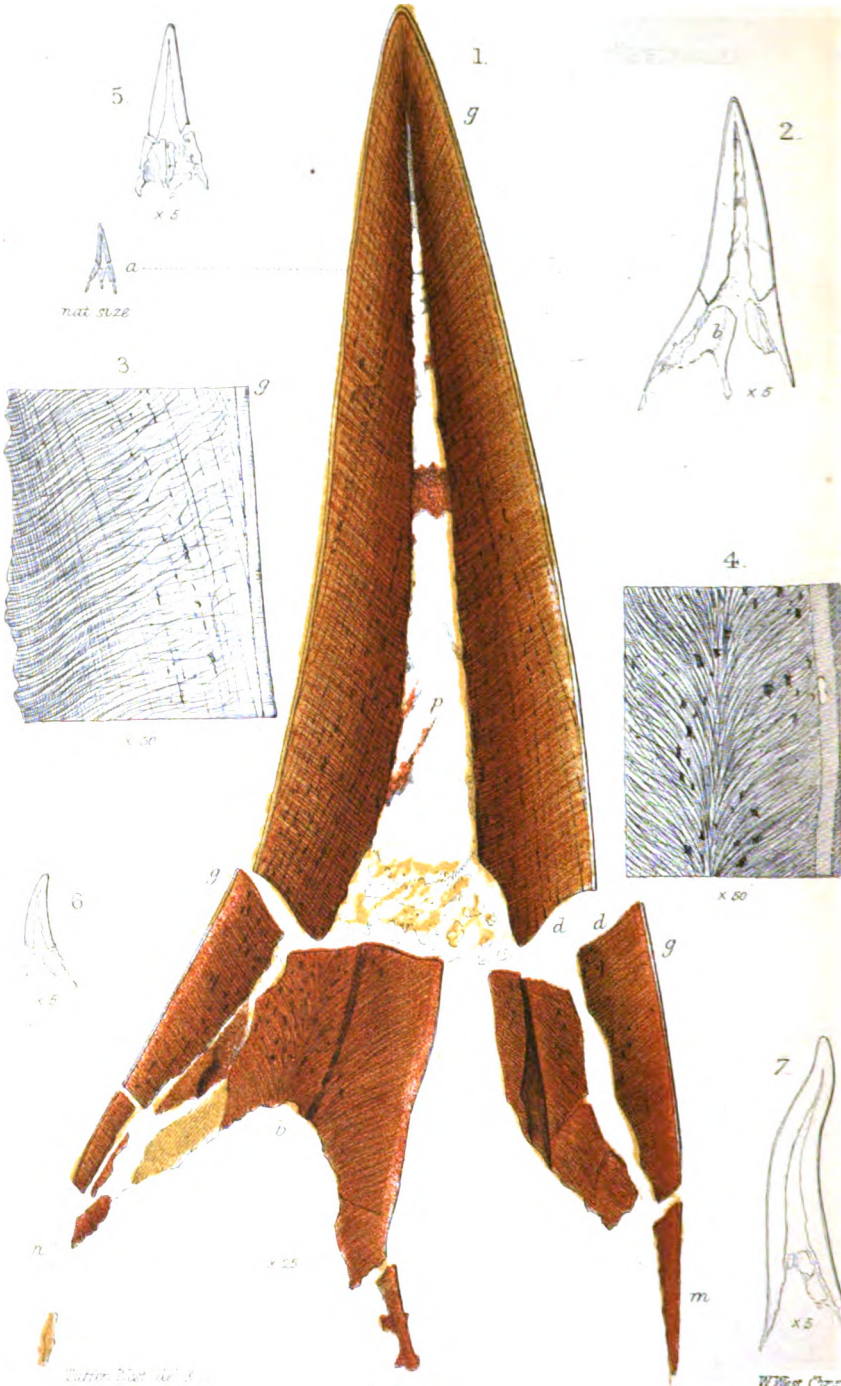

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PLATE VII.

Ganolodus Sicula.

Fig. 1.—A type-tooth, in longitudinal section, magnified 25 diameters: *a*, nat. size; *b*, part of parietal dentine near base of crown; *d*, *d*, dentine; *g*, *g*, ganoine; *p*, pulp-cavity; *m* fore, *n* hind, part of base of tooth.

Fig. 2.—Outline of the same tooth, magnified 5 diameters.

Fig. 3.—Section of ganoine and outer part of parietal dentine, magnified 50 diameters.

Fig. 4.—Section of inner or central part of dentine, near the apex of the tooth, magnified 50 diameters.

Fig. 5.—Outline of straight variety of tooth of *Ganolodus Sicula*, in longitudinal section, magnified 5 diameters.

Fig. 6.—Ib. of bent variety of ib. ib.

Fig. 7.—Ib. of wavy variety of ib. ib.

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PLATE VIII.

Mioganodus laniarius.

Fig. 1.—Crown of tooth, in longitudinal section, magn. 18 diams.: *a*, natural size; *b*, apex; *c*, base of enamelled summit of crown; *p*, pulp-cavity; *m*, fore, *n*, hind part of base of hollow, perhaps incomplete, crown.

Fig. 2.—Portion of enamelled summit of the same tooth, in longitudinal section, magn. 50 diams.: *g*, ganoine; *d*, dentine.

Fig. 3.—Portion of unenamelled base of ib. ib., magn. 50 diams.

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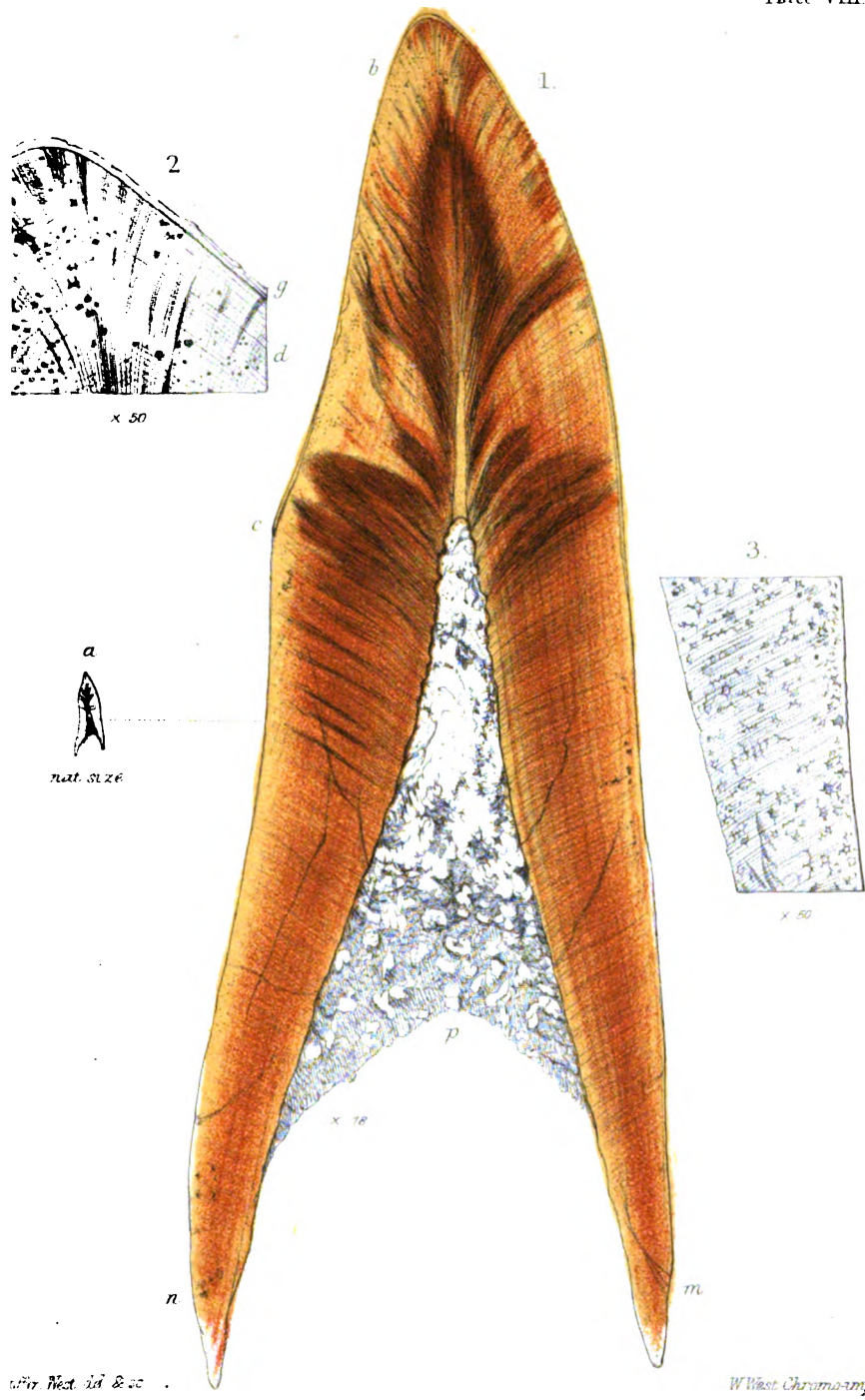

Wm. West. del & sc.
W West. Chromo-lith.

MIOCANODUS LANIARIUS

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T.Wm. del. & sc.

W.West. Chromo-ins.

AGANODUS APICALIS

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PLATE IX.

Aganodus apicalis.

Fig. 1.—Tooth and portion of bone, in longitudinal section, magn. 50 diams.: *a*, nat. size; *b*, compact osteo-dentine closing base of *p*, pulp-cavity; *d*, dentine; *o*, osseous tissue; *n*, base of tooth.

Fig. 2.—Outer portion of dentine of the same tooth, magn. 100 diams.

Fig. 3.—Dentine and osteo-dentine of the part of base of tooth (*n*, fig. 1), magn. 100 diams.

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PLATE X.

Aganodus undatus.

Fig. 1.—Tooth, in longitudinal section, magn. 50 diams.: *a*, nat. size; *b*, compact osteo-dentine closing base of *p*, pulp-cavity; *m*, fore, *n*, hind part of base of tooth.

Fig. 2.—Section of dentine near the apex of the pulp-cavity.

Fig. 3.—Section of remnant of pulp-cavity, *p*, and surrounding osteo-dentine.

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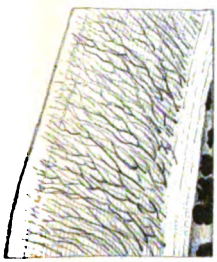

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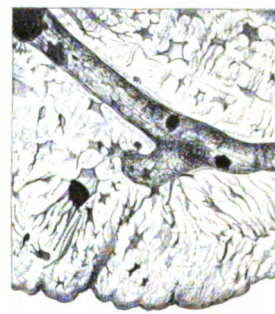

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AGANODUS - UNDATUS.

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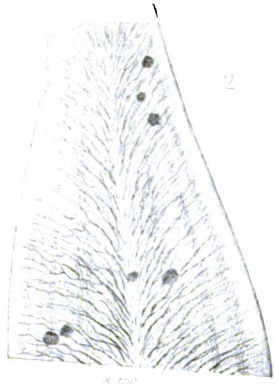

PTERINOPUS PRODUCTUS.

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PLATE XI.

Pternodus productus.

Fig. 1.—Tooth, in longitudinal section, magn. 25 diams.: *a*, nat. size; *b*, compact osteo-dentine closing base of pulp-cavity; *o*, osteo-dentine filling pulp-cavity; *p*, remnant of pulp-cavity in apical half of the crown; *o'*, osteo-dentine overlapping posterior expansion of dentinal part of base of tooth, *n*; *m*, fore part of base of tooth; *c*, osseous tissue of jaw.

Fig. 2.—Dentine of broken apex of the same tooth, magn. 100 diams.

Fig. 3.—Ib. of produced base, with subjacent, *o*, and overlapping, *o'*, osteo-dentine.

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PLATE XII.

Sagenodus inæqualis.

Fig. 1.—Alveolar portion of jaw with teeth, in longitudinal section, magn. 12 diams.: *a*, nat. size; *b*, *c*, *d*, *e*, *f*, *g*, teeth; *m*, fore, *n*, hind part of portion.

Fig. 2.—The tooth *d*, with subjacent part of jaw, magn. 50 diams.

Fig. 3.—Portion of hind part of base of the tooth *b* (fig. 1), magn. 100 diams.

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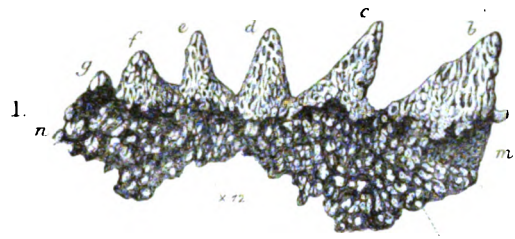

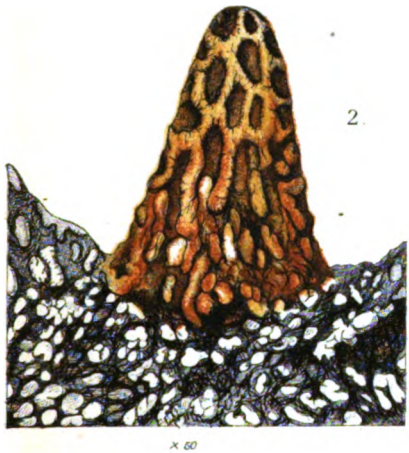

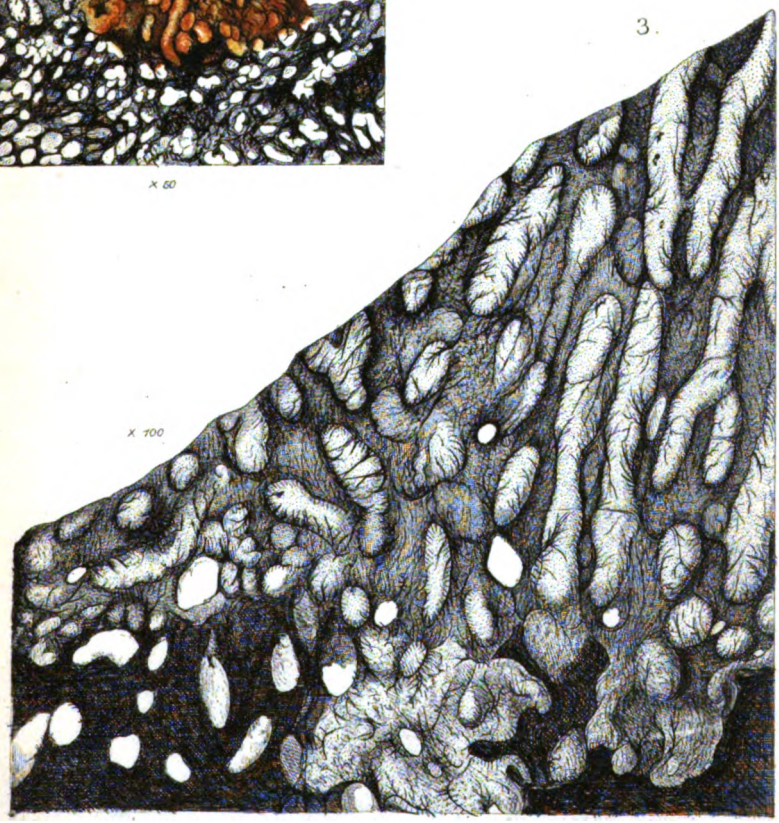

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SACENODUS INEQUALIS

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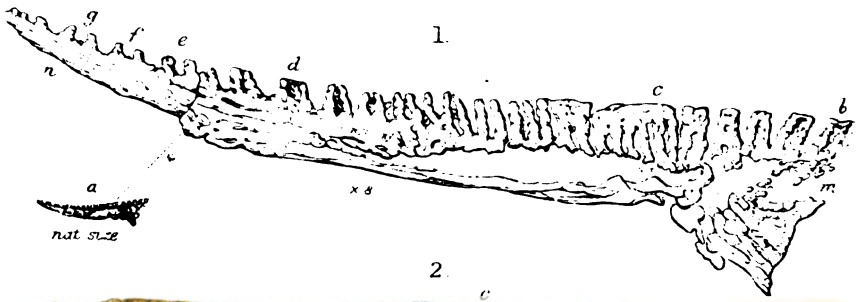

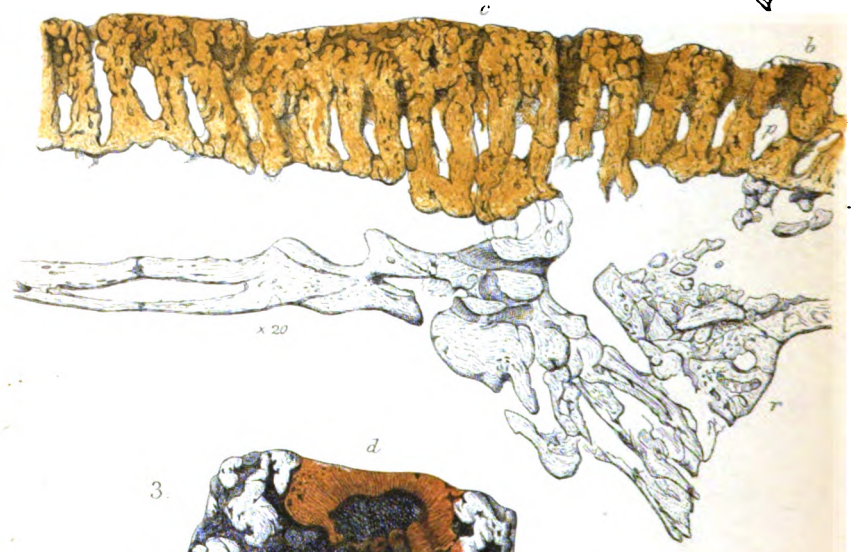

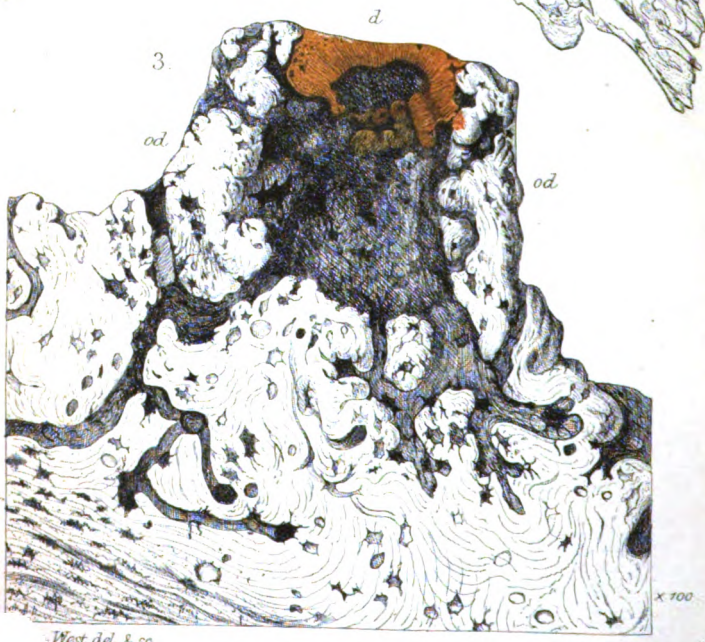

West del. & sc.

W.West, Chromo imp.

CHARACODUS CONFERTUS.

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PLATE XIII.

Characodus confertus.

Fig. 1.—Portion of dentary bone with bases of teeth, *b*, *c*, *d*—*g*, in longitudinal section, magn. 8 diams. : *a*, nat. size; *m*, fore, *n*, hind, part of jaw.

Fig. 2.—Bases of teeth, *b*, *c*, with subjacent bone, *r*, magn. 20 diams.

Fig. 3.—Base of teeth, *b*, fig. 1, with subjacent bone, *r*, magn. 100 diams. : *d*, dentine; *od*, osteo-dentine; the bone at *r* shows batrachoid radiate cells or "lacunæ."

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PLATE XIV.

Gastrodus præpositus.

Fig. 1.—Portion of (dentary?) part of jaw, with teeth, in longitudinal section, magn. 9 diams.: *a*, nat. size; *b*, anterior laniary tooth, *c*, *d*, *e*, *f*, *g*, *h*, smaller serial teeth; *m*, fore, *n*, hind part; *o*, osseous tissue of jaw.

Fig. 2.—The tooth *d*, fig. 1, magn. 50 diams.: *p*, pulp-cavity.

Fig. 3.—Basal part of the tooth, *b*, fig. 1; magn. 100 diams.; *d*, section of parietal dentine in the direction of the tubules; *t*, *t*, section of dentine across the tubules.

Fig. 4.—The tooth *c*, fig. 1, longitudinally bisected near the pulp-cavity, of which the apex is shown at *p*.

Fig. 5.—The tooth *e*, fig. 1, and alveolar process, magn. 50 diams.

Fig. 6.—The tooth *f*, fig. 1, and alveolar process, magn. 50 diams.

Fig. 7.—The tooth *g*, fig. 1, and subjacent bone, magn. 50 diams.

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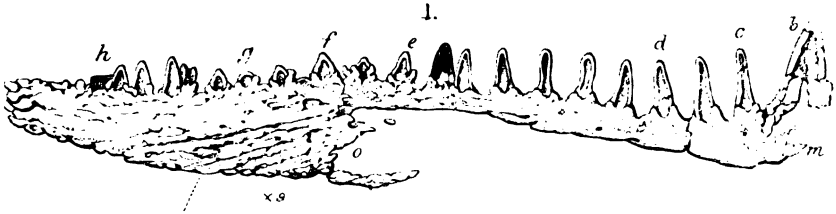

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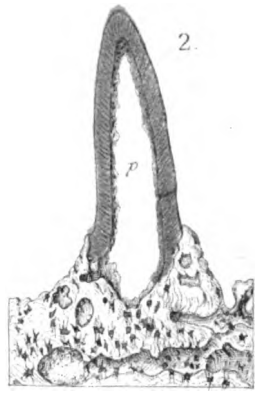

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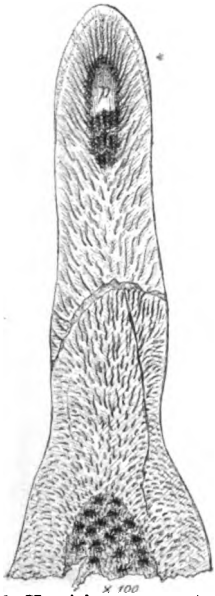

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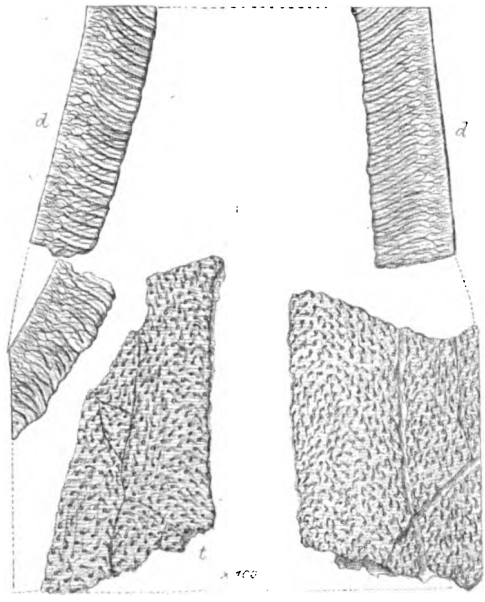

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Tuffen West del. & sc.

W West Chromo Lith

GASTRODUS PRÆPOSITUS.

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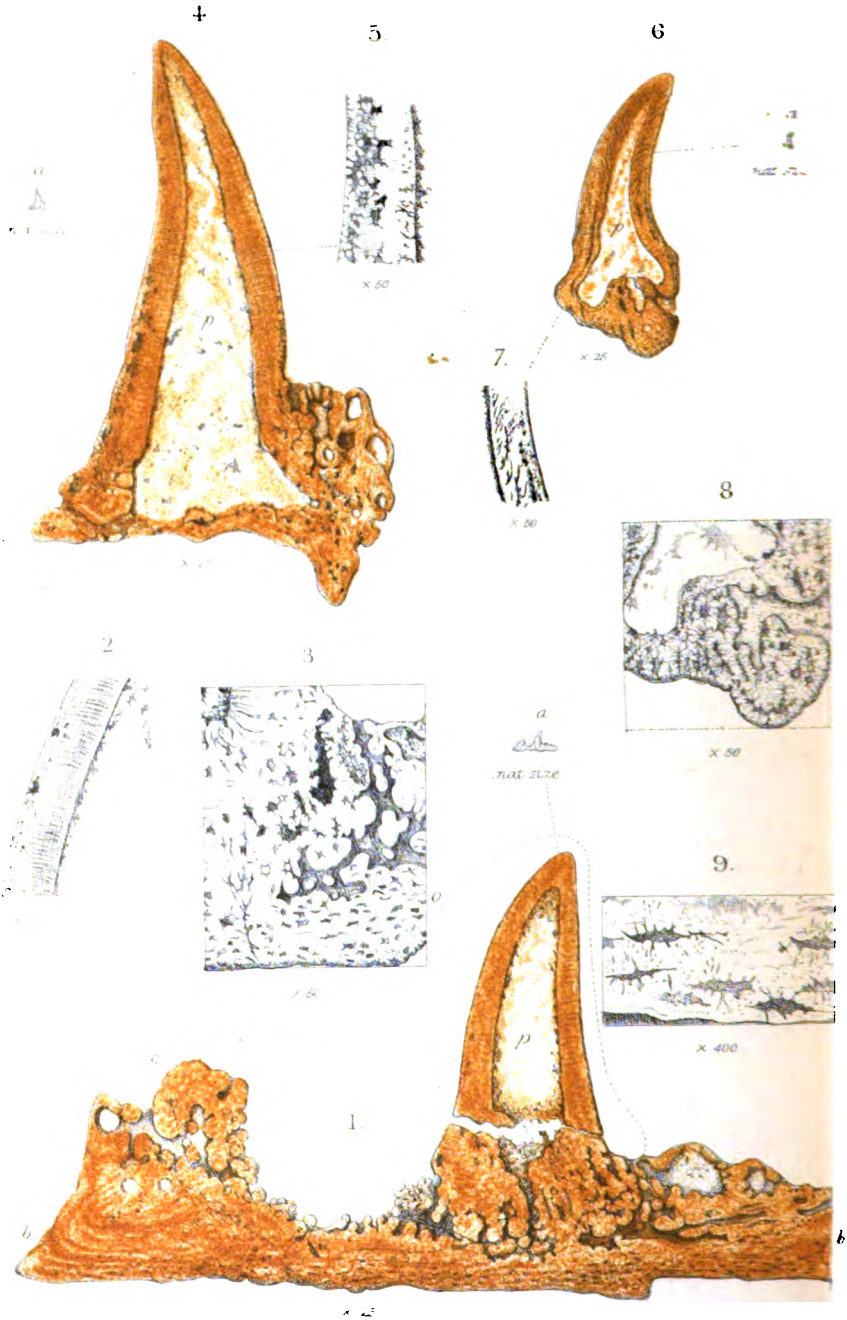

GASTROLUS FLABELLATUS

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PLATE XV.

Gastrodus præpositus.

Fig 1.—Portion of jaw, and serial tooth, in longitudinal section, magn. 25 diams.: *a*, nat. size; *b*, osseous tissue of jaw; *c*, part of alveolar process of a second tooth; *p*, pulp-cavity.

Fig. 2.—Portion of parietal dentine of tooth, fig. 1, magn. 50 diams.

Fig. 3.—Portion of jawbone from hind part of alveolar process of same tooth, magn. 50 diams.: *o*, denser tissue with batrachoid bone-cells.

Fig. 4.—A detached tooth, with confluent part of alveolar process, in longitudinal section, magn. 25 diams.: *a*, nat. size; *p*, pulp-cavity.

Fig. 5.—Portion of parietal dentine of same tooth, magn. 50 diams.

Fig. 6.—A detached tooth, with confluent part of alveolar process, in longitudinal section, magn. 25 diams.: *a*, nat. size; *p*, pulp-cavity.

Fig. 7.—Portion of dentine from fore-part of base, showing transition into osteo-dentine of the same tooth, magn. 50 diams.

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Fig. 8.—Portion of alveolar process of same tooth, mag. 50 diams.; showing large and tortuous vascular canals.

Fig. 9.—Portion of denser part of osseous tissue of fig. 1, magn. 400 diams.; showing batrachoid bone-cells in longitudinal section.

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